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Effectively Sustaining  
Forces Overseas  
While Minimizing  
Supply Chain Costs

Targeted Theater Inventory

Eric Peltz, Kenneth J. Girardini,  
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Prepared for the United States Army and the Defense Logistics Agency

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## Preface

Airlift or sealift can be used to ship supplies for military forces overseas with differential speed and cost. This documented briefing lays out a construct for designing a distribution network that divorces these transportation speeds from overall distribution speed and takes advantage of their respective strengths to meet combatant command needs while minimizing total distribution costs. In doing so, it provides recommendations for when and how the two transportation modes should be employed in concert with inventory management and positioning policies as part of an overall distribution network design.

The briefing that serves as the basis for this document represents a compilation of research sponsored by the Assistant Deputy Chief of Staff, G-4 (Project: Implementing the Ideal Supply Chain Structure) and the Commanding General, Defense Distribution Center (Project: Analytical Support for Strategic Planning). These projects have been conducted jointly within RAND Arroyo Center's Logistics Program and the Forces and Resources Policy Center of the RAND National Defense Research Institute (NDRI), respectively. RAND Arroyo Center, part of the RAND Corporation, is the Army's federally funded research and development center for studies and policy analyses, and RAND NDRI is a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Department of the Navy, the Marine Corps, the defense agencies, and the defense Intelligence Community. This document should be of interest to those engaged in supply chain management throughout the Department of Defense. The Project Unique Identification Code (PUIC) for the Arroyo project that produced this document is DAPRR06016.

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## Contents

Preface.....	iii
Summary.....	vii
Acknowledgments .....	xv
Glossary .....	xvii
1. INTRODUCTION AND BACKGROUND .....	1
2. DISTRIBUTION SYSTEM DESIGN TRADEOFFS .....	13
3. TARGETED THEATER INVENTORY INVESTMENTS.....	31
4. POLICY CHANGES TO LEVERAGE FORWARD DISTRIBUTION DEPOTS .....	47
5. SUMMARY OF RECOMMENDATIONS .....	52
Bibliography.....	55



## Summary

During Operation Iraqi Freedom (OIF), the costs of air shipments have garnered attention at different points for several reasons. These reasons include: shortfalls in overall funding—with transportation then becoming one of the reduction targets due to a perception of it being a discretionary cost with an ability to switch to lower-cost options, rising cost trends, and examples or anecdotes of what seem to be relatively unimportant items going by air. Regardless of the reason, each time these circumstances have arisen the first action has been to push for more items to be shipped via sealift.

This type of reaction should not be needed, though. With effective distribution network design, continually monitored and updated, items will be shipped via the ideal mode that meets customer response needs at the lowest total distribution cost possible—not lowest transportation cost. Thus, we recommend that Department of Defense (DoD) supply chain managers design the distribution system to meet customer needs driven by their operational requirements in a way that minimizes total costs, with continuous monitoring and adjustment. In doing so it will become clear that for the lowest total distribution costs to meet customer needs, some items should be sent overseas by air and some should be sent by surface but usually to intermediate theater-level inventory, not directly to units. Thus, the modal choice must be coordinated with global inventory management and stock positioning. This document builds on a previous report *Leveraging Complementary Distribution Channels for an Effective, Efficient Global Supply Chain* by examining in more depth how judicious overseas inventory positioning can reduce total supply chain costs and better align the use of air and sea lift with their ideal uses.<sup>1</sup>

### Distribution System Tradeoffs and Implications for Network Design

What are the cost and performance tradeoffs that should be considered in distribution network design? The first factor to consider is the tradeoff between

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<sup>1</sup> Eric Peltz and Marc L. Robbins, *Leveraging Complementary Distribution Channels for an Effective, Efficient Global Supply Chain*, Santa Monica, CA: RAND Corporation, DB-515-A, 2007.

replenishment or delivery time and the inventory needed to provide a desired level of customer service. As replenishment time increases, lead-time demand and lead-time variability increase, requiring more inventory for the same level of service. So this creates a cost tradeoff among supply chain options if different lead times have different costs. Another factor that affects costs is how many times something is handled, which increases with echelons of inventory. Thus, there are three costs to trade off—transportation, inventory, and materiel handling—in distribution system design. Performance can also be traded off against cost.

Let us now apply this to the distribution network that supports forces in Iraq to show how the tradeoffs can be applied to improve the distribution system. For equal performance, there are two main ways to provide service to Iraq that trade off these three costs. Centralized theater inventory replenished by surface (i.e., sealift) from the continental United States (CONUS), with intratheater air delivery to distributed aerial ports of debarkation (APODs) across Iraq, has lower transportation costs but higher inventory and materiel handling costs than delivery directly from CONUS to these APODs via strategic airlift. However, these costs vary greatly among items, so sometimes the difference in absolute transportation costs is greater than the difference in inventory costs and vice versa. Assuming responsive, reliable delivery is needed, for some items, the theater inventory with surface replenishment option will be cheapest. For other items, CONUS air without theater inventory is less expensive, depending upon item price, weight, cube, and the demand level. Using these characteristics, we can determine the ideal distribution network design option for each item. For a small, expensive item, inventory cost dominates the network's cost structure, so inventory cost tends to drive the decision on the best option—in this case, CONUS stockage with strategic airlift. For a heavy, inexpensive, high-demand item, transportation cost is the key cost driver, leading to a different optimal solution—theater inventory with surface replenishment.<sup>2</sup> If instead slower delivery is acceptable, allowing for a

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<sup>2</sup> For items for which theater inventory is deemed the most efficient model, a decision also has to be made on the theater inventory levels. The levels should be item dependent, with the levels being set to produce the optimal mix of support from theater and CONUS inventories from a cost standpoint. Theater inventory replenished by surface should

tradeoff between cost and performance, surface direct to units from CONUS can be the best option.

With these tradeoffs in mind, one can then design a distribution network, particularly where the stock is held and how it is shipped, that automatically meets customer needs while using the “right” modes in terms of minimizing total cost. With needs met, customers—units in the field—should not care how they get the materiel. In this construct, the role of customers is to communicate valid requirements. Then it is up to DoD global logistics providers to set up and maintain a network that meets needs as efficiently as possible, automatically, without lots of exception management or being forced to make trades between costs and meeting customer needs. If this is not done, then when an order comes in, a choice sometimes has to be made between paying more than should have been necessary to provide rapid delivery (i.e., using strategic airlift for an item that should have been in theater inventory) and delaying delivery to avoid paying the higher bill (i.e., using sealift for direct delivery to a unit).

## **A Decision Approach for CONUS vs. Theater Inventory**

We offer the following approach, based upon the theater demand history and item characteristics, to determine whether to position an item in theater inventory vs. CONUS inventory:

1. Determine the per-shipment transportation cost difference between strategic air and sealift with intratheater air. This should be based upon the actual costs to ship the item.
2. Develop forecasts of the theater fill rate for an item as the inventory level is increased and compute the associated annual inventory holding costs.
3. For each inventory level, determine the annual transportation costs, assuming non-theater fills are shipped from CONUS via airlift.
4. Determine the additional annual materiel handling costs associated with the additional receipt and issue transactions for replenishment shipments

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generally be set to fill predictable demand levels, with air from CONUS tending to handle spikes in demand that temporarily exhaust theater inventory.

from CONUS to a theater inventory site for each inventory level in step 2.

5. Determine the inventory level for which the total of the inventory holding, materiel handling, and transportation costs is the lowest. This payback period may be limited through the use of a maximum payback period to reduce inventory and thus financial risk, particularly when long-term demand levels are highly uncertain. For example, for SWA, we have employed a maximum payback period of two years in implementation efforts. If no inventory level produces a positive net benefit or meets the payback threshold, then the item should not be stocked in theater inventory with surface replenishment.

We illustrate this approach for deciding between CONUS and theater stockage with examples using shipments to Southwest Asia (SWA). A common vehicle battery weighs 89 pounds and has a price of \$113. The cost to fly the battery via military-managed strategic air averaged \$328 from January 2006 to January 2007. Every time a battery is flown, almost three more could be purchased instead for the amount of the airlift bill. And the theater inventory costs to relieve the air channel for each single shipment are much less than the cost of one battery, because the inventory continually turns over. In effect, each additional investment in a battery allows up to six demands per year to be satisfied from theater inventory, saving multiple air shipments. The optimal investment in theater inventory for this battery saves \$10.1 million per year in transportation costs, with additional annual inventory and materiel handling costs of about \$0.5 million for a substantial savings of about \$9.6 million per year.

Aircraft engines are big and heavy, so at first glance it seems they should be shipped overseas via sealift too. However, the Apache and Blackhawk engine, valued at about \$700,000 apiece, costs \$962 per pound to buy versus \$5 per pound to ship by air. Let us first examine what it would take for most engines to be issued from theater inventory. Purchasing additional engines to fill the surface pipeline for theater inventory and produce a high theater fill rate would require \$10.7 million in annual inventory holding costs while saving \$600,000 in air costs, for a net cost increase of \$10.1 million per year. Even at very low theater fill rates, the increased cost of inventory cannot be justified by

the decreased transportation costs, so this item should not be stocked in theater inventory with surface replenishment.

Using historical demand data, distribution system costs, and item price and weight data to compute the actual tradeoffs for all items shipped to SWA produces what tend to be logical classes for theater inventory. Items with high recurring demand and low price-to-weight ratios produce the greatest return on investment in theater inventory, with optimal solutions having very high theater fill rates. These include items such as track, tires, and packaged petroleum, oil, and lubrication products. Many engineered automotive products have lower total costs with theater inventory, but the relative return is smaller, along with lower optimal theater fill rate targets (e.g., 67 percent instead of 90 percent plus). Large but very expensive items such as the aircraft engine have increased supply chain costs, with theater inventory replenished by surface, regardless of the theater inventory level. Even more extreme examples of items with increased supply chain costs with theater stockage with surface replenishment are electronics and other small, expensive items.

## **Reducing Costs and Improving Distribution Performance in SWA**

We have been working with Department of Defense supply chain organizations to apply this methodology in SWA since early 2006, with significant progress having been made. Additional potential for improvement in SWA remains, though. At the end of 2007, we found that about 20,500 items should be stocked forward in SWA at the Defense Logistics Agency (DLA) warehouse in Kuwait (DDKS). In most cases, the need for theater inventory has been recognized, but in many cases, theater and/or global inventory levels have not been set high enough to enable replenishments to SWA upon demand, resulting in inventory stockouts even for items with nominally sufficient theater inventory requirements. Improving inventory depths and fine tuning the breadth by adding some additional items has the potential to further reduce strategic air shipments by about \$225 million per year. Using conservative assumptions for airlift costs from DDKS to units in Iraq and for inventory holding costs, the result would be a net savings of about \$100 million per year. This is on top of \$400 million per year in strategic airlift cost avoidance and \$200 million per year in net savings already being achieved through improved DDKS inventories.

Besides reducing costs, adding or increasing inventory of the 20,500 items will also improve distribution time in some cases. This is because many of these items are sometimes sent by sealift to theater, even for high-priority shipments (46,000 tons in 2007). With improved theater inventory, the distribution time for the portion of shipments currently going by sealift directly to units in SWA would dramatically improve, as the customers would instead get fast response from DDKS. This would potentially affect 36,000 tons of shipments per year.

## **A Standard Process for Determining Theater Inventory**

A standard process to plan and manage theater inventory should be adopted. It would start with periodic review and action by the agencies that manage the items to be forward positioned. The periodic review would identify the items for which theater inventory would produce lower total supply chain costs based upon transportation, inventory, and materiel handling costs and would simultaneously determine the associated inventory levels that would minimize total costs. This, in effect, focuses the theater stockage objective on the weight fill percentage, not requisitions filled—on minimizing distribution system costs, not inventory costs. Additionally, the managing agencies also need to set global inventory levels sufficiently high to have confidence that timely replenishment of forward positioned stocks can occur.<sup>3</sup>

## **Improving Forward Distribution Depot (FDD) Inventory Policy**

It is sometimes believed that FDDs, such as DDKS, provide a time advantage over CONUS. However, this is not always the case when compared with the response time provided by strategic air shipments from stock held at CONUS strategic distribution platforms (SDPs), the main Department of Defense distribution hubs. Generally, when the FDD can rely on a good scheduled truck-type network with frequent (e.g., daily) deliveries, the FDD does outperform the SDPs in terms of distribution speed. Otherwise,

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<sup>3</sup> Within DoD, wholesale inventory levels are typically set to achieve targeted fill rates without regard to where the fill comes from. Decisions on where to stock items have historically been based on demand percentages by region or proximity to repair or vendors to reduce first destination transportation costs. This is beginning to change as the services and DLA modernize their supply information systems.

performance is similar. For example, distribution times from the FDD in Kuwait and for air shipments from the SDP at Susquehanna, Pennsylvania (DDSP) to Iraq are similar. Likewise, distribution time from the FDD in Yokosuka, Japan and the SDP at San Joaquin, California to units in Okinawa and Singapore are similar. In contrast to these examples, the FDD in Germersheim, Germany provides faster response to units in Germany than does DDSP. As the benefits vary, so too should the stockage objectives for the FDDs.

As all FDDs present a total cost benefit, at least to some locations for selected items, the initial selection of theater inventory should employ the approach previously described. If the FDD also presents a distribution time advantage, then the stockage list might be expanded. Critical items that do not meet the FDD stockage criterion of reduced total supply chain cost could be added to theater inventory to gain a readiness benefit through faster distribution. If, however, the item does not meet the total cost criterion for theater inventory, this would increase costs, so a cost-performance tradeoff judgment will have to be made. How much, if any, additional cost is acceptable to gain the time advantage offered by the FDD? Additionally, for these items it could make sense to replenish the FDD by air to minimize inventory costs. If the item did not meet the total cost criterion for theater inventory, then this generally indicates that it is less expensive to fly the item to theater than to use surface along with additional theater inventory. Using air to replenish the FDD for these additional items would minimize the inventory investment while still gaining the FDD response time advantage.

### **The Financial Barrier of Different Budget Accounts**

Another potential barrier to effective DoD theater inventory positioning is associated with the different budget accounts that fund parts of the supply chain. The transportation savings resulting from forward stockage accrue to the service of the ordering unit through reduced over the ocean transportation (OOT) charges. Due to the nature of OIF, much of this benefit in SWA would accrue to the Army. However, increased inventory investment required to support forward positioning at DDKS has to be made by DLA through its working capital fund, the General Services Administration, and the Army, and, within the Army, the investment comes from the Army Working Capital Fund

while OOT is paid through the Office of the Deputy Chief of Staff, G-4 with operation and maintenance account dollars. In other theaters, different services would benefit to greater degrees, along with having to use some of their own working capital fund dollars. Thus, there could be a role for the distribution process owner (DPO) to advocate for increased working capital obligation authority and even upfront “cash” or total obligation authority, when needed, to seed theater inventory to reduce total distribution costs.

## **Conclusion**

In summary, based upon our analysis of shipments to SWA, as of the end of 2007, there were immediate additional opportunities to cut sustainment airlift by about two-thirds, cutting overall airlift about one-third or one or two strategic airlift flights per day, by improving SWA theater inventory. This does require inventory investment to be effective, and the strategic airlift savings would be partially offset by intratheater air costs. This will also improve requisition wait time (RWT) by shifting some shipments from surface direct from CONUS to customers to much shorter shipment times from DDKS. Longer-term, standard policy for FDDs should be agreed to, and it should be used to guide stockage decisions. Ultimately, the services’ and DLA’s enterprise resource planning based materiel planning systems should reflect this policy.

To better align incentives and responsibilities for FDD inventory management, the percentage of weight filled from each FDD should be established as a DPO metric, with results stratified by provider. Reports should be accompanied by the airlift cost and RWT impacts of shortfalls in theater inventory. Additionally, OOT costs should be borne directly by providers, rather than customers, as they are determined primarily by stock positioning. This would produce a better incentive for supply managers and organizations to minimize total distribution costs rather than focusing on minimizing inventory costs.

## Acknowledgments

After receiving an Operation Iraqi Freedom logistics research interim progress briefing in late 2003, MG Mitchell Stevenson, then Deputy Chief of Staff, G-3, U.S. Army Materiel Command, first requested our assistance with theater inventory planning. Under his direction, this led to initial changes in early 2004 and subsequent RAND support to the Defense Logistics Agency (DLA) for the initial inventory at the DLA distribution depot in Kuwait. When we identified shortfalls in theater inventory and lack of integrated transportation and inventory planning in 2006, Mr. Thomas Edwards, Deputy G-4 for Sustainment, U.S. Army, supported the follow-up research described in this documented briefing. As it progressed, BG Lynn Collyar, Commander of the Defense Distribution Center, supported the research, requesting methodological recommendations for DLA and requesting that we brief the DLA Corporate Board to help produce a common understanding of how global inventory planning, theater inventory planning, and distribution network design should be integrated.

Mahyar Amouzegar and Adam Resnick, at RAND, provided valuable technical reviews that led us to improve our methodological explanations and the overall description of the problem. Also at RAND, Rick Eden played a valuable role in helping us craft the briefing, Pamela Thompson formatted the document, and Nikki Shacklett edited it.



## **Glossary**

AMC	U.S. Army Materiel Command
APOD	Aerial Port of Debarkation
APOE	Aerial Port of Embarkation
BSM	Business Systems Modernization
CCP	Containerization and Consolidation Points
CONUS	Continental United States
DDJC	Defense Distribution Depot San Joaquin, California
DDKS	Defense Distribution Depot Kuwait, Southwest Asia
DDRT	Defense Distribution Depot Red River, Texas
DDSP	Defense Distribution Depot Susquehanna, Pennsylvania
DLA	Defense Logistics Agency
DPO	Distribution Process Owner
DS	Direct Support
FDD	Forward Distribution Depot
FOSP	Follow On Support Package
GS	General Support
GSA	General Services Administration
IHX	International Heavyweight Express
IPG	Issue Priority Group
LMP	Logistics Modernization Program
MALS	Marine Aviation Logistics Squadron
MEF	Marine Expeditionary Force
NIIN	National Item Identification Number
NMC	Not Mission Capable
OA	Obligation Authority
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OOT	Over the Ocean Transportation
PUK	Packup Kit
RO	Requisition Objective
ROP	Reorder Point
RSP	Readiness Spares Package

RWT	Requisition Wait Time
SDP	Strategic Distribution Platform
SMU	Supply Management Unit
SPOD	Sea Port of Debarkation
SPOE	Sea Port of Embarkation
SSA	Supply Support Activity
SWA	Southwest Asia
USA	United States Army
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy
USTRANSCOM	U.S. Transportation Command
WWX	Worldwide Express

## 1. Introduction and Background



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### ***Effectively Sustaining Forces Overseas While Minimizing Supply Chain Costs: Targeted Theater Inventory***

RAND

Forward Inventory-1

On 12 October 2006, in the face of what were viewed as excessively high air shipping costs to Southwest Asia (SWA) in support of Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF)—driven by examples of items being shipped by air for which expensive airlift seemed intuitively inappropriate, the Commanding Generals of the U.S. Transportation Command (USTRANSCOM), the U.S. Army Materiel Command (AMC), and the Defense Logistics Agency (DLA) sent a memorandum to the Commanding General of U.S. Central Command expressing an intent to work collaboratively to improve support while reducing air shipping to save money

and free airlift for other priorities.<sup>4</sup> To achieve this, the memo emphasized sending low-priority requisitions by surface, which it stated would reduce costs and reduce distribution times for high-priority items by freeing up capacity. It also mentioned reviewing items that are stocked centrally in the theater as another means for reducing airlift.

However, in ongoing research for the Deputy Chief of Staff, G-4, U.S. Army at the time of the memo's release, our analysis showed that there appeared to be a misconception that high air costs were being driven by high volumes of low-priority cargo going by air. We found that a significant portion of the *low-priority requisitions* are really for *high-priority cargo*, because there has been an inconsistency between some shipment priority codes and delivery timing needs for some orders by Army units. Simply shifting these shipments to sealift as suggested by the memo would have cut costs but degraded customer support. Furthermore, airlift volumes had little impact on transportation times, as airlift capacity was not constrained for most items because of the availability of commercial charter aircraft.<sup>5</sup>

Nevertheless, the same ongoing research found that the objective of the memo could be achieved—costs could be cut while improving customer support—by emphasizing the point about effective use of theater inventory. We had observed that there was a significant amount of *high-priority cargo that could be shifted to sealift while maintaining or even improving customer support effectiveness*. This represented a major opportunity to reduce costs while continuing to provide effective support. Further, *we observed a significant amount of high-priority cargo going by surface directly to theater customers, resulting*

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<sup>4</sup> Lieutenant General Robert T. Dail, General Benjamin S. Griffin, and General Norton A. Schwartz, "Transforming Priority Requisitions to Optimize Distribution," October 12, 2006.

<sup>5</sup> Generally, Air Mobility Command uses chartered aircraft to fly materiel to a regional base or airport, where it is transferred to military aircraft for the final leg into Iraq or Afghanistan. This minimizes the need for military aircraft. A small percentage of items, because of dimensions that prevent loading onto commercial cargo aircraft, do have to be flown from the United States on military aircraft. Overall, 71 percent of the airlift to SWA from CONUS for sustainment has been commercial from October 2001 through July 2007, with one month at 96 percent commercial. Demonstrating the ability to use commercial charter to surge, particularly when military aircraft are being used for other purposes, March 2003 had relatively high volume, with 93 percent commercial airlift.

*in poor support.* This resulted from pressure to reduce costs, but we found that most of the savings from this use of sealift could be preserved while providing this materiel to units in SWA much more quickly. This problem of poor support was just as important to address as unnecessarily high costs. In both cases, the solution is the same: sealift combined with improved use of theater inventory that is better aligned with global inventory planning as part of an integrated distribution network focused on minimizing total distribution costs to meet operational requirements. The high air costs highlighted in the memo were just one symptom of not taking this broad, integrated view. This documented briefing was developed to explain the issues with directly pursuing the strict guidance in the memo, to present the rationale for the recommended focus on theater inventory and how it should be integrated with the rest of the distribution system, and to lay out a path for achieving the objectives of better meeting customer needs while minimizing resource requirements, particularly in SWA, but also globally.

## Overview

- **Goals**
  - Meet operational requirements
  - Minimize total supply costs to do so
- **We provide recommendations to achieve these goals**
  - Immediate actions that can be taken by
    - National providers to reduce strategic airlift by about a third, saving a roughly estimated \$100M per year net of strategic air reduction, intratheater air increase, and inventory increase
    - Customer actions to further reduce costs
  - Longer-term policy changes for system design and operation to meet service level needs at lowest cost
- **We address questions raised with respect to**
  - Why all low-pri orders shouldn't automatically be sent by ship
  - Financial and inventory needs to achieve supply chain goals

RAND

Forward inventory-2

The overall objective should be to design a distribution system that meets operational requirements in a way that minimizes total costs. Pursuing how to achieve this objective reveals the ideal role for theater inventory—when and how to use it and when its use would be suboptimal—and when different transportation modes should be used. Well-targeted theater inventory, tied to global supply planning, is crucial to minimizing the total costs to meet the readiness needs of units overseas. It enables the ideal mix of reliance on inventory and different transportation options.

After explaining the principles that lead to this conclusion, we describe how they can be applied and the benefits that could result from full implementation in SWA. While significant progress in improving theater inventory had been made, as compared to 2007, we see an opportunity for a two-thirds reduction in strategic airlift for sustainment in SWA, amounting to a one-third reduction in overall strategic airlift or one or two strategic airlift

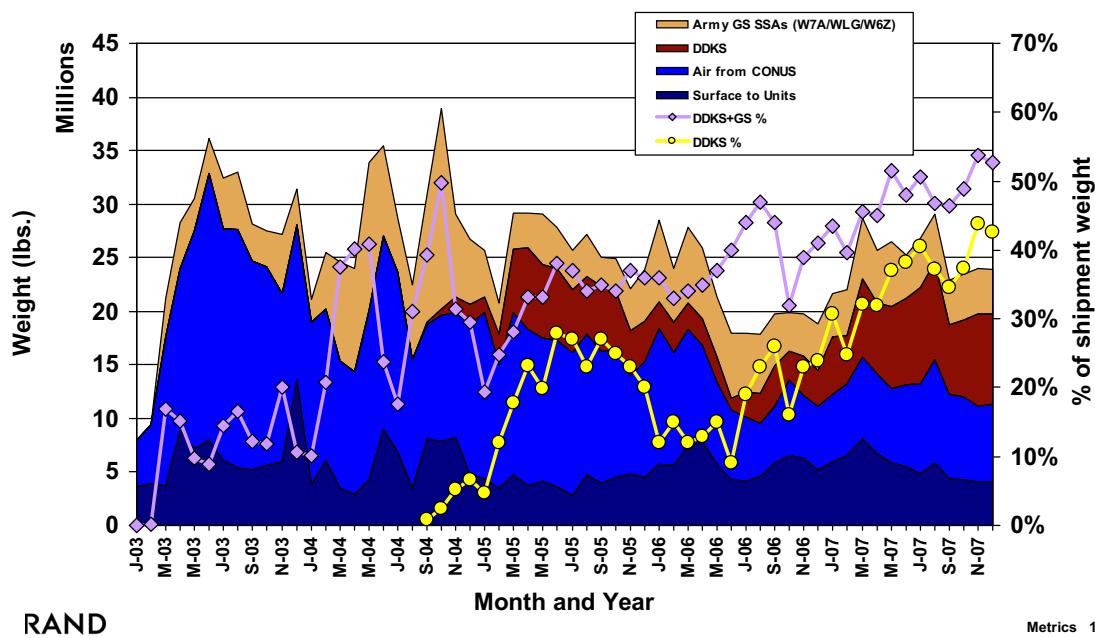
flights per day.<sup>6</sup> After accounting for increased intratheater air and inventory costs that will enable this strategic airlift reduction while preserving or improving customer support effectiveness, the savings, conservatively, would still be about \$100 million per year. From a longer-term perspective, we provide recommendations for policy changes that will continuously drive system design toward the best distribution network structure for every theater.

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<sup>6</sup> About half the strategic airlift has been to deliver new items, such as route clearance vehicles or vehicle add-on armor kits, to meet emergent, immediate needs.

## OIF Fill Rate by Weight Emphasizes Importance of Forward Stocking for Cost/Performance Benefits

Class II, IIIP, IV (less lumber/plywood), and IX shipments to Kuwait and Iraq  
 CONUS air: DLA consignor less armor kits as proxy for sustainment materiel  
 Other materiel tends to go surface (majority of surface volume): class I, lumber/plywood (IV), V, VII



To set the stage, this chart provides sustainment shipment mode trends for deliveries to units in Iraq and Kuwait. It includes materiel classes II (clothing, individual equipment, tools, administrative supplies), IIIP (packaged petroleum, oils, and lubricants), IV (construction and barrier materiel) excluding lumber and plywood, and IX (repair parts). Lumber and plywood are excluded because they, like food and ammunition, are almost always shipped via sealift, while the transportation mode for the other items tends to depend upon the situation.<sup>7</sup> The area time series show shipping weight by month to customers in Kuwait and Iraq since the start of 2003 by mode, with the dark blue showing surface or sealift shipments from the continental United States (CONUS) sent directly to customers with lengthy distribution times, the bright blue indicating air shipments from CONUS, the dark brown showing Defense

<sup>7</sup> Food has relatively dependent demand and thus tends to be pushed. Ammunition and bulk construction supplies have traditionally been stocked in theater with sealift-based replenishment due to their high weight.

Distribution Depot Kuwait, Southwest Asia (DDKS) shipments, and the light brown showing shipments from the Army general support (GS) supply support activities (SSA) in Kuwait.

In mid to late 2003, with the very high levels of airlift shown on this chart, Army airlift bills were exceeding \$100 million per month. In late 2003, RAND Arroyo Center analysis, as part of a project on identifying key issues in OIF logistics, showed that a significant portion of this was for relatively heavy but inexpensive items that ideally should have been delivered quickly upon demand from theater inventory, with the theater inventory replenished by sealift from CONUS. Early in OIF, initially through the early delivery of afloat war reserve sustainment stocks, the Army established GS SSAs in Kuwait to provide centralized theater inventory. But although the GS SSAs had a wide range of items, they did not stock many of the airlift drivers and had insufficient inventory of others.<sup>8</sup>

Also, in December 2003, the Army calculated that it would deplete all operation and maintenance funds well before the end of the year, pending additional supplemental funding. Thus, the Vice Chief of Staff of the Army requested a review to identify spending cut opportunities, with several areas, including airlift to SWA due to the high percentage of shipments by air, specifically identified for examination. In March 2004, with the Army spend rate continuing to outpace available funding, the Army's leadership reemphasized the need for cost control where possible, with the high airlift percentage identified again as a target.

As a result of the pressure to find ways to cut costs, there was some initial discussion of shifting some shipments from air to surface to save money. Instead, to help address the airlift cost problem without impeding support effectiveness, Arroyo recommended adding big, heavy but relatively inexpensive items to the GS SSAs to be replenished by surface, thereby cutting airlift bills but not impeding support effectiveness. In an expedient analysis in late 2003, Arroyo then provided a recommended stockage list to Army Materiel Command, which owns all of the inventory in the GS SSAs, based upon the

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<sup>8</sup> See Eric Peltz, Marc Robbins, Kenneth Girardini, Rick Eden, and Jeffrey Angers, *Sustainment of Army Forces in Operation Iraqi Freedom: Major Findings and Recommendations*, Santa Monica, CA: RAND Corporation, MG-342-A, 2005, for an overview of the initial standup and use of the GS SSAs.

top 800 inexpensive, airlift volume drivers. The Army added these items at recommended levels for items for which stock was on hand in sufficient quantity in CONUS to fill the surface pipeline for the transit to SWA without drawing down all of the stock. Low national stock levels due to the OIF demand surge were, however, a significant constraint.<sup>9</sup>

As these big, heavy items arrived by ship in Kuwait at the GS SSAs, the percentage of shipment weight coming from theater inventory climbed to almost 40 percent, as shown by the purple line series and right y-axis scale. Shortly thereafter, DLA established a forward distribution depot (FDD) in Kuwait, DDKS, to take over the centralized theater inventory mission from the Army GS SSAs, with the yellow line series showing the percentage from DDKS.<sup>10</sup> Most Army GS inventory levels were phased out, with levels for Army-managed items in the repair parts GS SSA transferred to DDKS.<sup>11</sup> The general supplies (classes II, IIIP, and IV) GS SSA was phased out completely, but the Army repair parts GS SSA continued operations as a “theater retention” SSA. That is, items no longer needed by direct support (DS) SSAs throughout Iraq and Kuwait were sent to the GS SSA for redistribution in theater. Later, the Army established a GS SSA in Balad, Iraq to handle part of the retention mission. Inventory held at DDKS and the GS SSAs helped bring down the sustainment lift.

When DLA established DDKS, Arroyo again provided initial inventory recommendations, this time covering the top 7,000 items in volume by weight. Thus, the percentage of weight provided from theater inventory should have increased above that seen in the chart. The problem was that many inventory requirements “on the books” for DDKS were not filled, which arose from not linking national inventory requirements to theater needs. That is, many items authorized to be forward positioned at DDKS were never on-hand there at sufficient levels to meet a majority of demand from units in theater, because

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<sup>9</sup> This is discussed in Eric Peltz et al., *Sustainment of Army Forces in Operation Iraqi Freedom: Major Findings and Recommendations*.

<sup>10</sup> The Army continued use of another GS SSA with aviation repair parts.

<sup>11</sup> Requisition objectives were maintained in the repair parts GS SSA for a small number of items to provide direct support to some maintenance activities in Kuwait. These are being transferred to another SSA in mid-2007. The aviation repair parts GS SSA was also maintained and continues to operate as of the writing of this document.

national-level inventory levels were never high enough to cover the sealift-based lead-time demand. This was later followed by insufficient updating of theater inventory requirements and a divergence in the theater inventory strategy from a concentration on adequate inventory of big, heavy items to one focused on expanding the number of items stocked. The stockage list expanded to about 40,000 items but with insufficient quantities of big, heavy, high-demand items, resulting in the need to fill demands for these items from CONUS stocks. The inventory policy that led to this problem stemmed from a misperception of a response time advantage for theater stocks over strategic airlift from CONUS, along with a lack of full appreciation for the role of theater inventory in distribution system costs. Both of these issues will be addressed in the next chapter.

Starting in late 2006, we began working with DLA, the Army Materiel Command, and the General Services Administration to apply the methodology or change their methodologies for theater inventory to reflect the detailed optimization methodology described in Chapter 3. As shown by the time series shown by purple line segments and diamonds, as of late 2007, this has led to close to 55percent of shipment weight to Iraq and Kuwait coming out of DDKS. However, further potential for improvement remains.

## ***Items Sent by Air Are in Two Categories, with Potential Reductions for Each Remaining***

- **About \$670M in airlift charges, 2007 (Source: GATES SU\_AP)**
- **~50%: Regularly ordered sustainment materiel**
  - **Air results from**
    - **Being lowest total supply chain solution for item (air best)**
    - **Theater/global inventory shortfalls (potential air reduction)**
- **~50%: Large, one-time or infrequent requirements, for example**
  - **Vehicles (e.g., new anti-IED vehicles)**
  - **Armor kits (about 50% in Nov/Dec & 40% for last 6 months)**
  - **Air results from**
    - **Critical emergent requirement/new capability (air best)**
    - **Planning shortfalls (potential air reduction)**

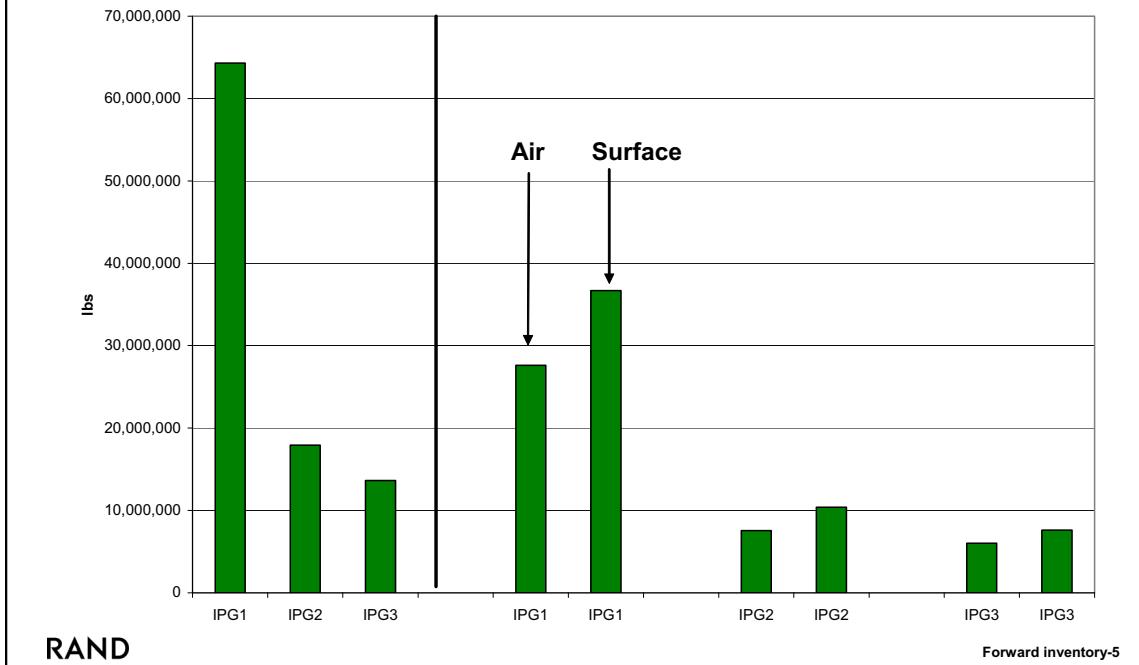
RAND

Forward inventory-4

So even with the improvements that have been made, substantial opportunity remains to cut sustainment airlift, which ran about \$340 million in charges to customers for shipments to Iraq and Kuwait in 2007, while providing more effective support. About 50 percent of the strategic airlift has been for sustainment. In some cases, using strategic airlift is part of the best, lowest-cost supply chain solution. In other cases, the use of strategic air for delivery to customers is driven by theater and national inventory shortfalls. And again, many high-priority items have been sent by sealift directly to units to avoid even greater airlift costs. The remainder of the strategic airlift has been for the one-time requirement type lifts for critical emergent needs for which strategic air is often the best solution. However, while not the subject of this report, there may also be cases where better planning and coordination could limit this airlift without impeding the ability to meet customer needs.

## ***There Is Also a Large Amount of High-Priority Cargo Being Shipped Via Sealift***

CONUS shipments to Iraq by weight, Jan-Oct 2006



As mentioned earlier, excessive airlift costs is not the only transportation “choice” problem. There is also the opposing issue of not using responsive distribution for high-priority materiel. By weight, over half of the highest-priority cargo (issue priority group 1—IPG1) is being shipped directly to customers in Iraq via sealift from CONUS, with transshipping of containers to trucks in Kuwait. These shipments take two to three months to get to units. A significant proportion of these shipments are coded as IPG1 with a required delivery date of 999, indicating that the shipment is needed to return a not mission capable end item to mission capable status. Additionally, as we will discuss later, many of the low-priority IPG3 shipments are actually to replenish tactical inventories with critical parts, with these slow surface shipments often resulting in tactical units running out of inventory and thus also impacting readiness. Further, this graph implies that shipment priority has little to do with whether an item is shipped via air or surface. In fact, further analysis shows that the primary driver is shipment weight. For IPG1 shipments going

to Army units in OIF in 2007, average requisition wait time (RWT) for defense transportation system shipments under 1,500 pounds was 26 days, for those between 1,500 and 5,000 pounds it was 53 days, and for those over 5,000 pounds it was 70 days.

In this report, we discuss improving performance for the high-priority shipments being sent by sealift in a way that does not significantly increase total supply costs. In ongoing research for the Deputy Chief of Staff, G-4, U.S. Army, we have also been examining the modal choice logic and execution selection processes at the time an item is shipped to develop recommendations for improvement in logic and process effectiveness when longer-term inventory planning to address this problem falls short.

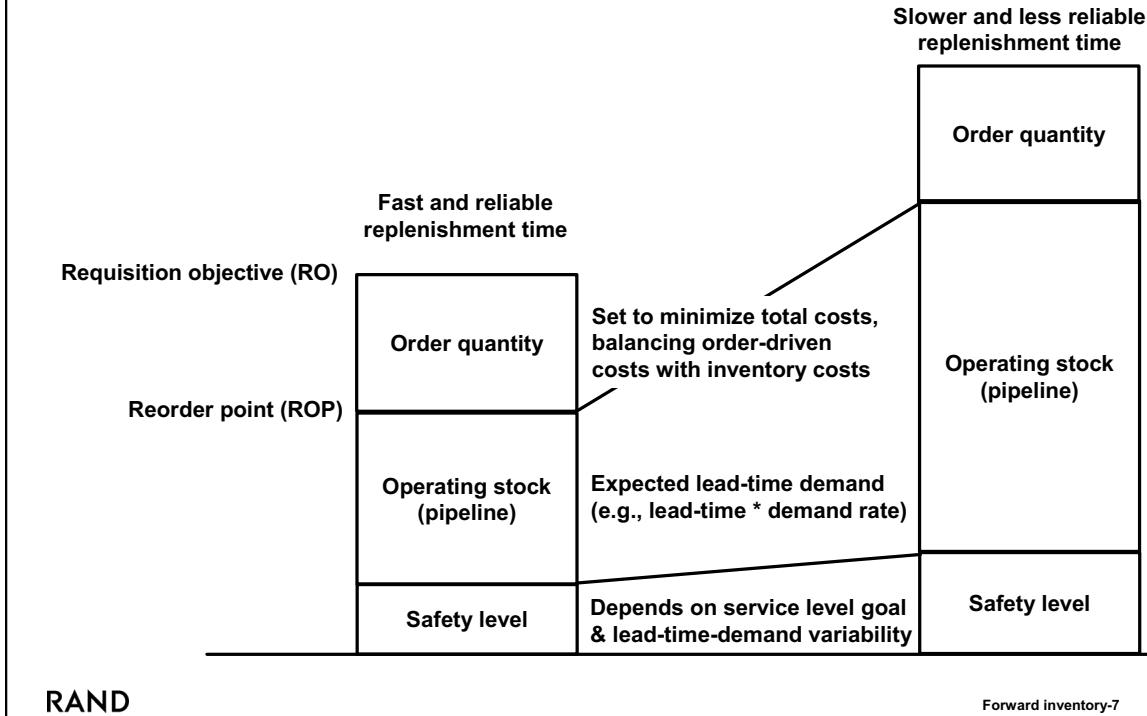
## 2. Distribution System Design Tradeoffs

### ***Outline***

- ➡ • Distribution system design tradeoffs
  - Reducing total supply chain costs through targeted theater inventory investments and surface replenishments
  - Policy changes to leverage forward distribution depots
  - Recommendations

The second chapter of this documented briefing provides a discussion of how the capabilities and costs of different distribution options can be leveraged in developing an optimal distribution network design. The third chapter presents an application of the resulting decision criteria to OIF sustainment flows to identify recommendations for improved theater inventory for reduced costs and better distribution performance. The fourth chapter discusses the issue of more broadly incorporating these criteria into policy and standard processes to continually leverage FDDs to best effect. The final chapter concludes with recommendations.

## ***Increasing Replenishment Lead-Time Drives Up Inventory Needs for a Given Service Level***



With regard to distribution network design, the first underlying factor is the tradeoff between replenishment or delivery time and the inventory requirements necessary to provide a desired level of customer service. In general, there are three components to inventory requirements. In the middle of the “stack” is operating or pipeline stock that has to cover the expected lead-time demand, which can often be thought of as just the delivery time multiplied by the demand rate. In a perfect world, one could just order this amount a lead-time in advance of a projected need and it would arrive just in time. However, the delivery time and the demand rate usually have some variability. Safety stock is added to account for some portion of the typical variability, and it is set at a level calculated as necessary to provide a specified level of service (e.g., being able to provide materiel on demand 85 percent of the time). The higher the variability in either delivery time or demand or the higher the desired confidence of having material in stock, the greater the safety stock needs to be. The sum of the operating and safety levels is the reorder

point. Added to this is an order quantity based upon providing the best balance between order-related costs and inventory holding costs.<sup>12</sup> It applies the same principles that we all use when we go to the store. For example, people buy a case of oil or box of nails rather than one at a time, as they do with more expensive items such as a computer.

So as replenishment time increases, lead-time demand increases and usually lead-time variability increases as well, requiring more inventory investment and higher inventory holding costs for the same level of service. This creates a cost tradeoff among supply chain options if options with different lead times have different costs.

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<sup>12</sup> When inventory is procured it actually represents an investment in accounting terms. The cost of holding the inventory consists of the storage or warehouse costs, insurance, shrinkage (e.g., theft), financing charges or the value of the money used to make the investment, obsolescence, and writeoffs from forecast errors. A discussion of inventory holding costs and the other inventory concepts discussed here can be found in most production and operations management textbooks such as James R. Evans, David R. Anderson, Dennis J. Sweeney, and Thomas A. Williams, *Applied Production and Operations Management*, 3rd ed., St. Paul, MN: West Publishing Company, 1984.

## ***Every Sustainment Item Has an Ideal Supply Chain Design for a Specified Service Level***

- **Total distribution network costs minimized by trading off:**
  - Transportation costs
  - Inventory holding costs
  - Materiel handling costs
- **For equal performance:**

Serve units from ...	Transportation	Inventory	Materiel handling
Theater inventory, surface replen	Lower	Higher	Higher
CONUS via air	Higher	Lower	Lower

- Lowest total supply chain cost solution varies among items depending upon item cost, weight, cube, and demand level
- Also depends upon theater conditions (e.g., threat)

Item characteristics	Transportation	Inventory	Materiel handling
Small, expensive item		Key cost	
Heavy, low \$, high-vol item	Key cost		

- Alternatively, trade off performance: surface to units from CONUS

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Forward inventory-8

Another factor that affects costs is how many times something is handled, which increases with echelons or layers of inventory. Thus, there are three costs to tradeoff—transportation, inventory holding, and materiel handling—in distribution system design. For equal performance, there are two main ways to provide service to units in SWA that trade off these costs. Theater inventory replenished by surface from CONUS has lower transportation costs but higher inventory holding and materiel costs than delivery directly from CONUS to distributed aerial ports of debarkation (APOD).

The amount that the transportation and inventory costs change between the solutions depends upon the item price, weight, cube, and demand level. For some items, the theater inventory/surface option will be cheapest, as the transportation cost decrease outweighs the increases in the other costs. For other items, CONUS inventory with strategic air to the unit is cheaper from a total distribution system standpoint. By looking at item characteristics, we can determine the ideal distribution plan for each item. For example, for a small,

expensive item, inventory cost dominates the distribution cost structure, so it drives the decision on the best distribution system design option. For a heavy, inexpensive item, with high demand, transportation cost is the key cost driver, leading to a different optimal option. If instead slower delivery is acceptable, then a solution with lower transportation, inventory, and materiel handling costs can be best, trading off performance for reduced cost. This option would be surface direct to units from CONUS.<sup>13</sup>

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<sup>13</sup> If strategic airlift, sealift, or theater inventory space were constrained, the problem would become different. For example, if airlift were constrained, more items might need to be placed in theater inventory to achieve the requisite responsiveness, or choices might have to be made among items in terms of which would be more important to deliver quickly. Generally, in this case, though, we are facing a fairly unconstrained problem. Most items can be shipped from CONUS to the region using commercial charter flights, with ample private-sector capacity to draw from. This limits the need for military aircraft to short regional flight segments and preserves military aircraft for a small number of items that have to be shipped that way due to commercial aircraft limitations, such as handling oversized/outsized cargo or carrying hazardous or classified materials. Warehouse space in Kuwait has also not been constrained and can be added via construction, outdoor storage, or leasing as needed. In a conflict in which commercial assets could not be used, capacity could become constrained. In such cases, the same basic concepts could be used to determine the optimal stock positioning and mode for each item, but then prioritization would have to occur, forcing some items into slower delivery (surface direct for a high-priority item) or more costly distribution situations (strategic air instead of theater inventory or theater inventory for an expensive item). Prioritization could be done based upon potential airlift consumption, cost impact, or item importance, depending upon what is considered most critical.

## ***Customers Drive Requirements, System Design Should Drive Modes***

- **Good distribution system design and stock positioning will seamlessly and automatically produce the “right” mode choices**
  - With responsive support that meets requirements, customers should not care how or from where materiel is shipped to theater
  - Mode use problems and challenges represent malpositioned stock, customer planning problems, and policy and process issues
- **Role of customers**
  - Communicate valid operational requirements
    - Need something as soon as possible
    - Need something by a certain date based upon plans
    - Would like to get something but timing is not critical
  - Specify delivery restrictions, consolidation, and location preferences
  - Plan activities in advance, when possible
- **Role of national providers: system design and management to**
  - Meet operational needs (timing, restrictions, consolidation, delivery loc)
  - Meet customer requirements as efficiently as possible

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Forward inventory-9

With these tradeoffs and distribution mode capabilities in mind, one can then design a distribution network that automatically meets customer needs and minimizes total cost by using the “right” transportation modes and inventory locations for each item. With their needs met, customers should not care how they get the materiel. Things like “air challenges” (i.e., criteria that require air shipments to be reviewed for a potential shift to surface to save money) then often represent a flaw in design or execution, such as malpositioned stock.

In this construct, the role of customers is to communicate valid requirements. Given current levels of Department of Defense distribution system process capability, there are really three levels of speed requirements that matter:

- The customer needs something quickly,
- The customer needs something by a certain date—which only really matters if the date is far enough in advance to allow for surface, and

- Timing is unimportant to the customer.<sup>14</sup>

Customers should also coordinate delivery needs and should try to plan major projects as far in advance as possible. Then it is up to national providers to set up a system to meet needs as efficiently as possible, automatically, without lots of exception management or being forced to make trades between costs and meeting customer needs.

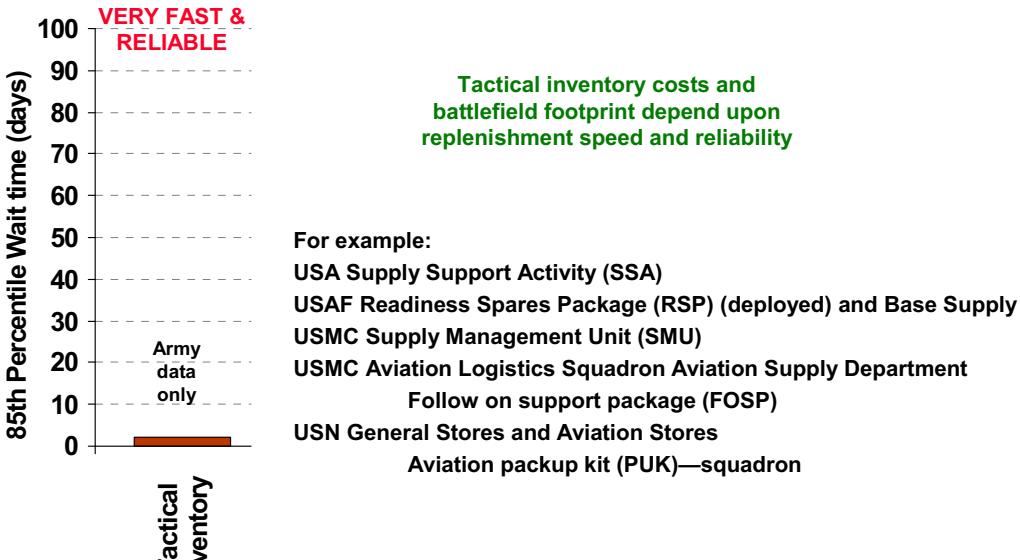
In contrast to this, we sometimes see or hear about customers making requests of national providers that run counter to the best system design. For example, they might ask for expensive, low-demand items to be placed in theater inventory. Providers, in good faith, may mistakenly work to satisfy their customers by executing plans that precisely reflect the request. Instead, they should say, “We understand what you want, but we can meet this need more effectively in another way. This alternative solution will provide faster response and lower total cost.”

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<sup>14</sup> See Eric Peltz and Marc L. Robbins, *Leveraging Complementary Distribution Channels for an Effective, Efficient Global Supply Chain*, Santa Monica, CA: RAND Corporation, DB-515-A, 2007, for a discussion of distribution process capabilities to SWA for different modes and customer types.

Customers can communicate requirements through requisition priorities and required delivery dates (RDDs). While there are three general priorities in the DoD system, from a distribution standpoint, IPGs 1 or 2 would fall into the “customer needs something quickly category” and IPG3 should signify that timing is unimportant. An RDD could be used for project planning when a customer needs something by a certain date. This would be most meaningful if the date is beyond the sealift delivery window, which would enable the RDD to be used with IPG3. The only incentive for the units to order with the correct priority is to “do the right thing,” because over the ocean transportation bills are paid centrally and inventory holding costs are spread across all customers as part of transfer prices.

## All Services Use Tactical Inventory to Meet Critical Personnel and Equipment Needs



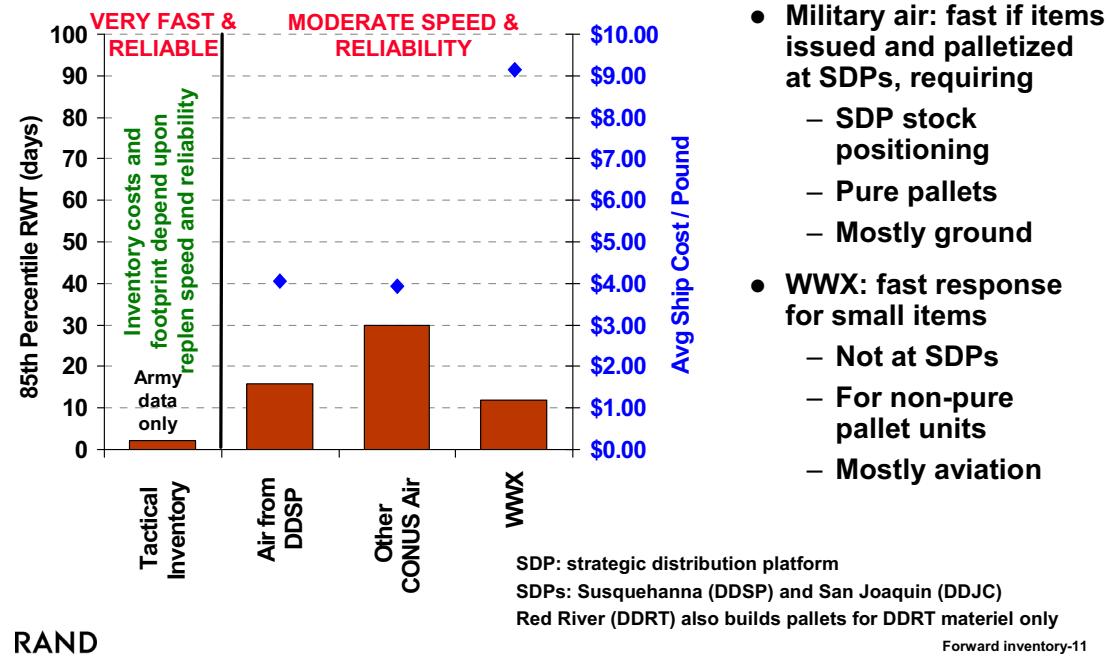
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Forward inventory-10

To make the tradeoffs in an actual situation, we need to understand the specific distribution network mode options and costs. For SWA and other theaters, there is just one option for very fast and reliable service: tactical inventory held directly by units, which is akin to retail-level inventory. For the Army, as shown on this chart, wait time is usually one or two days. While tactical inventory has different names and different inventory policies for the different armed services, inventory at this level is used by all services to meet critical, immediate equipment, operational, and personnel needs such as repair parts for not mission capable (NMC) vehicles, oil to top off engines, concertina wire for a hasty defense, or even toilet paper. The costs and battlefield footprint—the space required—of these tactical supply activities depend upon replenishment speed and reliability.

## CONUS Stocks with Strategic Air Provide Responsive Replenishment & Direct Support

Shipments to Iraq, May – Oct 06



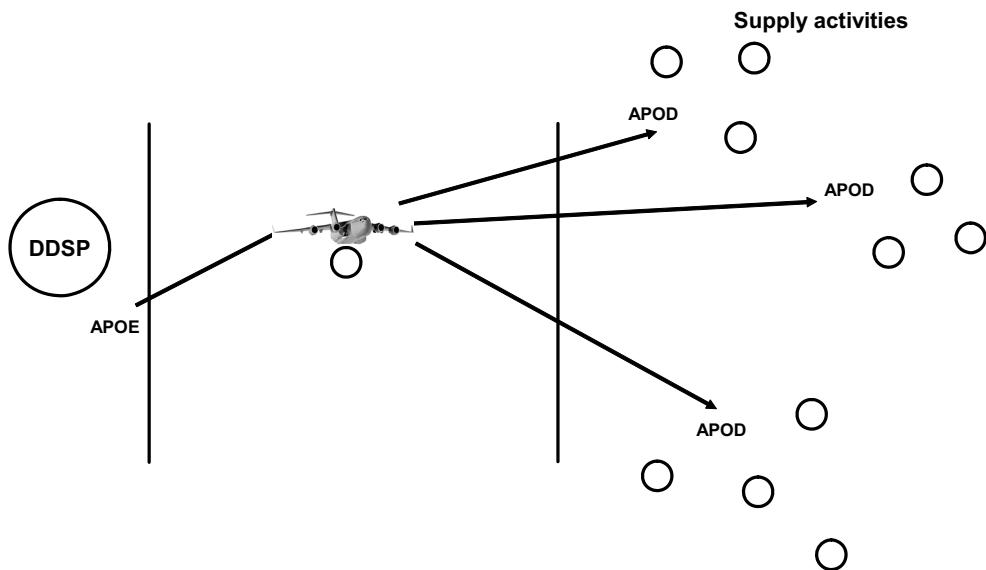
One way to keep tactical inventories relatively small, which is sometimes desired for deployability as well as to facilitate tactical mobility for ground units, is replenishment via air from CONUS. For Iraq, as shown by the 85th percentile requisition wait time (RWT) on the left-axis scale, pure pallets (i.e., materiel for a single Army SSA or Marine SMU) of materiel issued from the SWA-supporting strategic distribution platform (SDP) at Susquehanna, Pennsylvania provide relatively responsive replenishment for tactical inventory and effective direct support to units for items not in tactical inventory. However, being able to rely upon pure pallets from the SDP is dependent upon sufficient unit volume and good SDP stock positioning. For low-volume units or ones for which materiel is not stored at SDPs, a higher-cost alternative for items weighing up to 300 pounds, running around \$9 per pound instead of about \$4, as shown on the right y-axis scale, for similar or better responsiveness

is worldwide express (WWX) and international heavyweight express (IHX).<sup>15</sup> When neither option applies, CONUS air RWT is significantly longer, as shown by the “Other CONUS air” column. This would be the case for pure pallet customers when materiel is not issued from the supporting SDP or cannot be put into pallets by DLA and must go instead to an aerial port of embarkation (APOE) for pallet building. An example for which the latter case would apply is hazardous materiel. For WWX/IHX customers, other CONUS air applies for low-priority shipments or shipments of items greater than 300 pounds.

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<sup>15</sup> WWX and IHX are blanket contracts with commercial, premium express shippers for items up to 150 and from 150 to 300 pounds respectively.

## ***With Air Used for Replenishments, Supply Activity Footprint Is Minimized***



This slide schematically depicts the air replenishment option for supply activities in SWA, as just described. Materiel is shipped from DDSP to supply activities through an APOE in the United States to APODs throughout the region. With the response times for the strategic air options, the en route inventory pipeline, symbolized by the small circle underneath the aircraft, and the amount of inventory in each supply activity is minimized.

## ***Some IPG3s Are Critical Replenishments for Tactical Inventory with Relatively Thin Depth***

- **Army**
  - SSAs in each brigade combat team and support brigade (24 in Iraq)
  - Assume 20-day replenishment times
  - Focused on readiness drivers
  - IPG3 (low priority) replenishments
- **Air Force**
  - RSPs at squadron level and base supply (4 in Iraq)
  - Assume 30-day replenishment time
  - IPG2 replenishments
- **Marine Corps**
  - Supply management unit (SMU) for MEF ground (1 in Iraq)
  - IPG1 replens in Iraq, Pendleton, Lejeune, & Okinawa; IPG2 in Hawaii
  - Aviation supply department, MALS for wing (1 in Iraq)—no IPG3
- **Navy**
  - IPG2 when the stock goes below the safety level and due-in is not anticipated to arrive prior to reaching zero balance; otherwise IPG3

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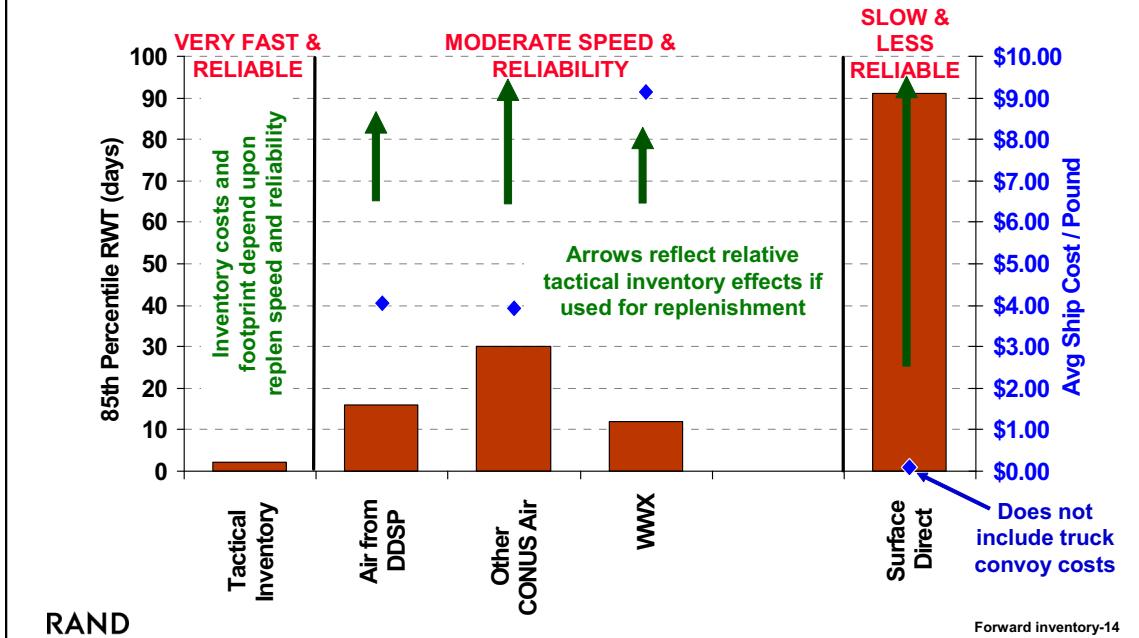
Forward inventory-13

However, despite planning for 20-day replenishments and focusing tactical inventory on readiness drivers, the Army codes replenishments as IPG3, which is considered low priority. This includes the Army SSAs in Iraq, which numbered 24 as of early 2007, plus more in Kuwait as well as Afghanistan. Low priority is generally considered appropriate for surface, but that would produce replenishment times inconsistent with inventory plans. Other service units in Iraq use high and medium priorities—IPG1 and 2—for inventory replenishments. The Army IPG3 is helpful for stock rationing when items are in short supply nationally. When an item is in short supply nationally, it is better to hold the item centrally rather than replenish one or two SSAs and making inventory unavailable to other Army units. Item managers can use the IPG3 indication for this purpose. However, it is not a useful signal for distribution, as will be discussed. These low-priority requisitions are not for low-priority items or a signal that slow replenishment is acceptable.

## Surface to Tactical Inventory Would Not Meet Current Inventory Planning Parameters

Direct Surface Should Be Targeted for Long-Lead Planned Projects and Non-Critical Items

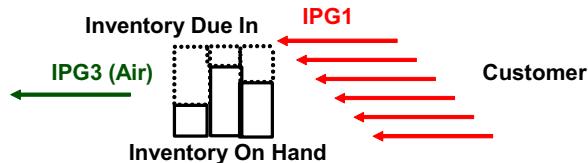
Shipments to Iraq, May – Oct 06



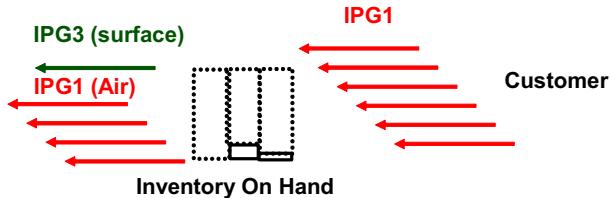
As shown by the distribution time for surface direct on this chart, if IPG3 replenishments were sent via surface, the times would not meet inventory planning parameters, degrading customer support with respect to readiness drivers. Instead, direct surface is useful for long-lead planning projects and low-priority items.

## Surface IPG3 Replenishments Without Increasing Inventory Will Not Reduce Air

- Multiple IPG1 customer requests are filled by the SSA, which is replenished with a single IPG3 replenishment



- Switching to surface with same inventory requirement will deplete inventory, resulting in IPG1 customer requests passing through to wholesale



Example: Truck battery  
Large replets sent by surface  
Total SSA ROP/RO: 4111/4516  
17 of 25 SSAs in SWA are 0 balance  
(another 5 are very low)  
60 vehicles NMC for this battery  
(as of 10 Jan)  
4369 due-outs to customers  
8372 due-ins to SSAs

ASL – Authorized stockage list of parts in the SSA

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Forward inventory-15

Let us take a look at what would happen if (and when) IPG3 replenishments automatically went surface from CONUS without increasing tactical inventory. The top part of the chart shows how SSA inventories are designed to work. IPG1 requests come in from customers within a brigade and should be filled from on-hand stocks. Then a replenishment order goes out when the inventory position hits the reorder point. If the inventory is planned at 20-day replenishment but surface with a longer replenishment time is used, on-hand stocks will get severely drawn down, ultimately to zero. Replenishments will eventually come in, but they will tend to fill “due-outs” to customers and will be quickly drawn back down.

When a customer order comes in to an Army SSA and the on-hand is zero, the SSA immediately sends a replication of the customer order to the national level. Thus, SSA stockouts lead to small, high-priority orders sent to the national level for delivery by air or from theater stocks. In effect, a policy to move IPG3 requisitions for inventory replenishment will lead to worse

customer support, as strategic air and theater inventory fills take longer than fills from SSA inventory, and will often only delay the use of air and the associated costs.

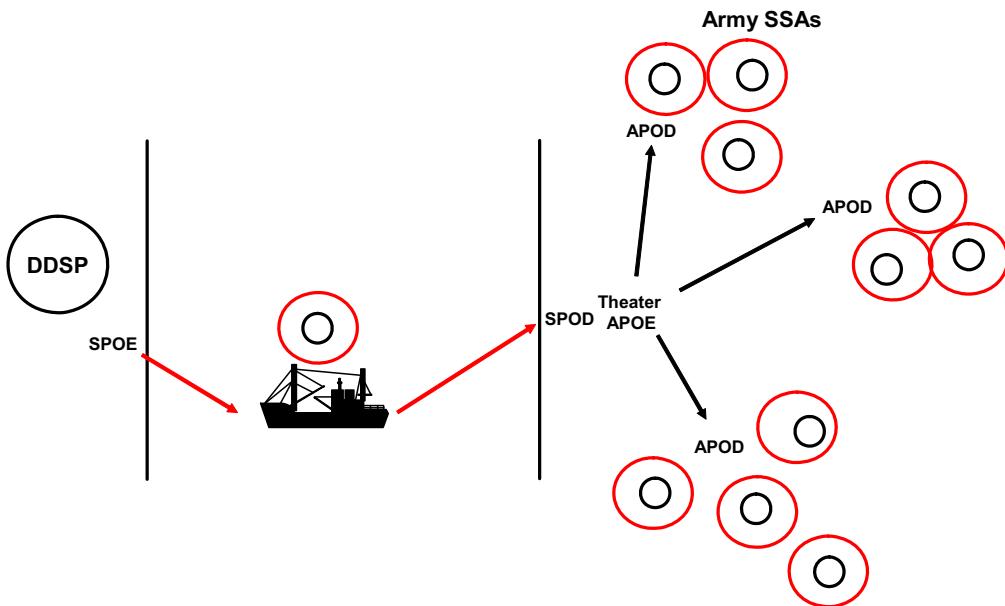
A vehicle battery provides a concrete example. Due to what are known as air challenge criteria—rules the Army has set up to determine when shipments should go surface, many tactical inventory replenishments for Army units with a total shipment weight of 1,500 pounds or more were shipped by surface in 2006 and early 2007, including many replenishment shipments of this battery.<sup>16</sup> The result is that many battery replenishments were shifted to surface transportation for delivery from CONUS to SSAs. Thus, despite an average SSA requirement of close to 200, 17 of 25 SSAs in Iraq and Kuwait that stock the battery were zero balance—out of stock—in early January 2007, with 5 more SSAs almost out of stock. As expected, this then resulted in many small orders going directly to the national system, which have been sent to customers by air. On 10 January 2007, as a sample snapshot, 60 vehicles were reported NMC for this battery, with many more batteries owed to customers.

In effect, IPG3 should not be used for Army tactical inventory replenishments given current Army tactical inventory planning parameters, the importance of most items held in tactical inventory, and desires to keep battlefield “footprint” relatively small. The Army has recognized the need to make this change and is in the process of making system changes to change the priority of tactical inventory replenishments to IPG2.

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<sup>16</sup> In the spring of 2007, the rule driving the use of sealift in this case was dropped, with additional changes in Army transportation mode policy, which governs air challenge criteria, being considered.

## ***With Surface for All Replenishments, Iraq SSAs Would Need \$700M More in Inventory***



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Forward inventory-16

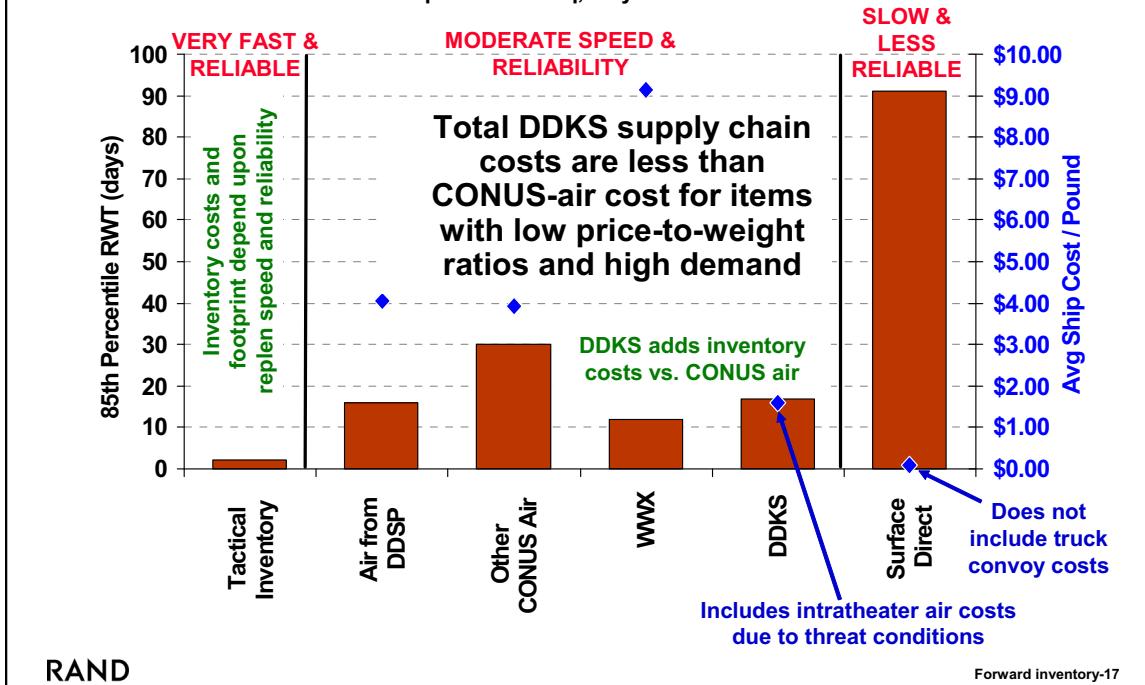
This slide returns to the schematic for distribution to SWA, illustrating the effect that replenishing by surface instead of air would have on inventory requirements through the larger circles. To maintain the desired level of customer service with direct surface replenishments would require another \$700 million in SSA inventory in Iraq, also increasing footprint.<sup>17</sup>

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<sup>17</sup> The general intent of ongoing policy changes is to provide rapid replenishment to SSAs through improved theater inventory and changes in transportation policy to almost all SSA replenishments to be shipped by air when the item is not in theater. However, as a backup plan, the 20-day cap for SSA inventory planning was lifted in July 2007, with item depths based upon actual times by item.

## Theater Stocks with Surface Replenishment Also Provide Responsive Support

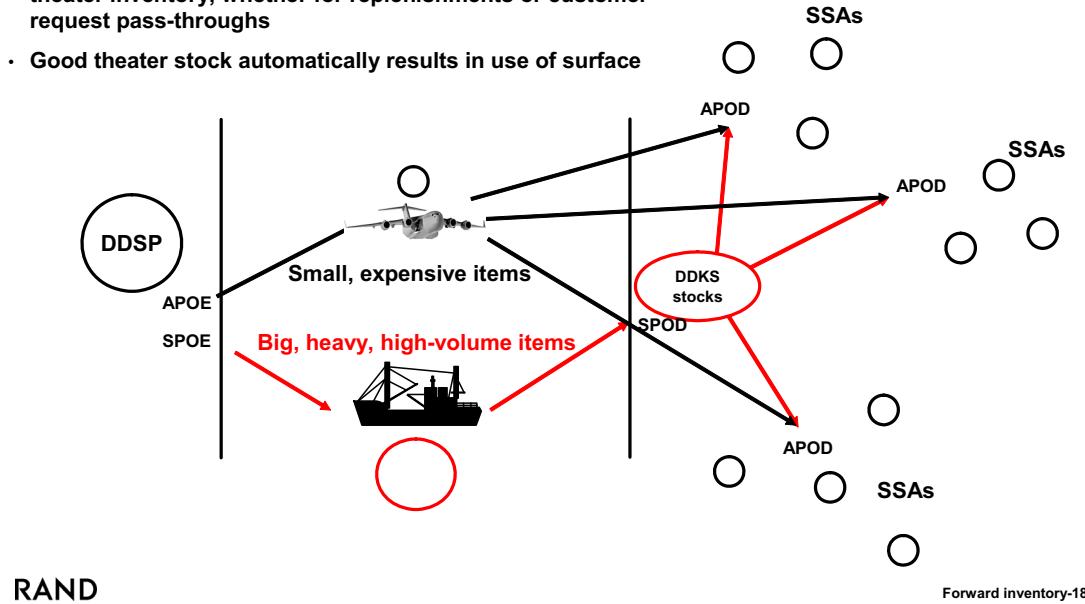
Shipments to Iraq, May – Oct 06



Forward stockage at the theater level in DDKS allows surface replenishment to be delinked from tactical inventories, with RWT from DDKS comparable to shipments from CONUS by air. Including intratheater air costs of about \$1.65 per pound, transportation costs associated with DDKS are quite a bit lower, but using DDKS effectively does require additional inventory that may or may not be more costly than the strategic air savings, depending on the item. As will be shown in more detail later, total distribution costs when using DDKS are lower for low price-to-weight items and vice versa.

## ***DDKS Stocks for Bigger, Heavier Items Keep SSA Depth Low While Enabling Surface Replenishment***

- Key is responsive replenishment, not air replenishment
- Search patterns for air-coded (ALOC) SSAs will first look to theater inventory, whether for replenishments or customer request pass-throughs
- Good theater stock automatically results in use of surface



Adding theater inventory with comparable responsiveness to strategic air allows for a dual delivery system to tactical inventory locations that leverages their respective cost structure advantages, with small, expensive, low-demand items going by air and big, heavy, high-demand items being delivered upon demand from DDKS. For Army units, when a requisition goes out from the SSA—whether a replenishment or a customer pass-through, an automated search pattern first checks DDKS, so the right inventory at DDKS automatically results in the right items going by surface in response to SSA orders (i.e., sealift is used for DDKS replenishments) and other items being shipped via air from CONUS stocks.

### 3. Targeted Theater Inventory Investments

#### *Outline*

- **Distribution system design tradeoffs**
- ➡ ● **Reducing total supply chain costs through targeted theater inventory investments and surface replenishments**
- **Policy changes to leverage forward distribution depots**
- **Recommendations**

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Forward inventory-19

This chapter turns to the specifics of how these distribution system design concepts should be applied for OIF to produce near-term cost reductions and performance improvement. It also explains a decision approach that we used to develop DDKS recommendations and that could be used more broadly with respect to using theater inventory to optimize distribution costs.

## ***Inventory, Transportation, and Materiel Handling Cost Tradeoff Analyses Reveal Best Stock Locations***

Shipments Jan 06- Jan 07 (not all shipments went air), Inventory costs include in-transit and on-hand

<ul style="list-style-type: none"><li>• <b>Truck Battery</b><ul style="list-style-type: none"><li>– Weight: 89 lbs</li><li>– Unit price: \$113; \$1.27/lb</li><li>– Airlift cost: \$328; \$3.68/lb</li><li>– Shipped: 60,309</li></ul></li><li>• <b>Total annual savings from theater inventory: <u>\$9.6M</u></b><ul style="list-style-type: none"><li>– Estimated transportation savings per year: \$10.1M</li><li>– Estimated annual cost for theater inventory: \$0.3M</li><li>– Estimated handling costs: \$0.2M</li></ul></li></ul>	<ul style="list-style-type: none"><li>• <b>Apache &amp; Blackhawk Engine</b><ul style="list-style-type: none"><li>– Weight: 722 lbs</li><li>– Unit price: \$694,615; \$962/lb</li><li>– Airlift cost: \$3,550; \$4.92/lb</li><li>– Shipped: 314</li></ul></li><li>• <b>Total annual additional cost of theater inventory: <u>\$10.1M</u></b><ul style="list-style-type: none"><li>– Estimated transportation savings per year: \$0.6M</li><li>– Estimated annual cost for theater inventory: \$10.7M</li><li>– Estimated handling costs: \$5K</li></ul></li></ul>
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Forward inventory-20

We illustrate a decision approach for determining whether or not to stock an item in theater inventory with two examples. The vehicle battery from the earlier example weighs 89 pounds and has a price of \$113. The cost to fly a battery via military-managed strategic air averaged \$328 from January 2006 to January 2007. Every time a battery is flown, almost three more could be purchased for the cost of the airlift. Plus, the required theater inventory costs to relieve the air channel are much less than the cost of one battery because the inventory continually turns over. In effect, each additional investment in a battery allows several demands per year to be satisfied from theater inventory. Specifically, each increase in the number of batteries held in inventory requires an investment equal to the cost of one battery. Then every time a battery is sold to a customer, the proceeds enable replenishment—the investment is made just once.

Based upon the demand level and variability and the replenishment lead time for DDKS, we calculated that the optimal average amount of additional

inventory that should be either on hand in DDKS or en route on a ship would be about 13,500 batteries, which would provide a theater fill rate of about 98 percent and about five inventory turns per year.<sup>18</sup> Given a 98 percent fill rate from theater with the remaining 2 percent sent by air from CONUS and assuming 100 percent intratheater air from DDKS (the actual level has been 65 percent) at \$1.65/pound and sealift costs averaging \$0.12/pound, investment in theater inventory saves \$10.1 million per year in transportation costs. With 20 percent annual inventory holding cost, the inventory holding costs work out to about \$0.3 million (average on-hand or in the pipeline \* cost \* holding cost %). To determine materiel handling costs, we estimated the number of replenishments that would be sent to DDKS per year, adding an issue and receipt cost for each one using DLA net landed cost tables, which are activity-based costs used to charge for distribution center work.<sup>19</sup> This produced

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<sup>18</sup> The tradeoff between transportation savings versus increased materiel handling and inventory costs are a function of item characteristics (cost and weight), actual air costs for that item (e.g., batteries that “weigh out” an air pallet cost less per pound to ship than bubble wrap, which will “cube out” an air pallet), and the demand rate and variability. For items with the same overall demands, items with less variable demands will get additional inventory turns and hence greater transportation savings from the same inventory level. The total costs associated with different levels of theater inventory for an item can be computed, with forecast error, enabling an optimal level to be established. In general, each additional increase in the inventory level results in lower expected transportation savings as the predicted inventory turns for each additional item goes down. For this analysis, the computations were done by analyzing the lead-time demand quantities associated with surface replenishment using a technique called lead-time bucketing. Statistical filtering (Winsorizing) was used to eliminate outlier demand quantities that could not be reliably forecast to recur. Lead-time bucketing to set ROPs using demand histories is described in unpublished research on *Improving the Supply Chain for TRIDENT Submarines*, by Kenneth Girardini, Carol Fan, and Elvira Loredo, that was conducted for the Office of the Logistics Support Coordinator in the Navy’s Strategic Systems Programs office and that led to changes in inventory management for TRIDENT refit facilities in 2000. For a discussion of using Winsorizing with demand data for inventory determination, see Kenneth Girardini et al., *Dollar Cost Banding: A New Algorithm for Computing Inventory Levels for Army Supply Support Activities*, Santa Monica, CA: RAND Corporation, MG-128-A, 2004.

<sup>19</sup> With an order quantity of 1,877, there would be a projected 32 replenishments per year, with the total issue and receipt costs for each replenishment coming out to \$5,112 using DLA fiscal year 2007 net landed costs.

estimated additional materiel handling costs of about \$0.2 million. The result is a substantial savings of about \$9.6 million per year for theater inventory versus shipping batteries exclusively by air from CONUS.

Aircraft engines are big and heavy, so at first glance it might seem they should go by surface lift to theater inventory as well. However, the high-altitude T701D engine for the Apache and the Blackhawk costs \$962 per pound to buy versus \$5/pound to ship by air. Purchasing additional engines to fill the surface pipeline for theater inventory to achieve a theater fill rate of about 85 percent would require \$10.7 million in annual inventory holding costs while saving \$600,000 in transportation costs, for a net cost increase of \$10.1 million per year. Materiel handling costs are relatively inconsequential for this item in comparison to the other costs. Continually reducing the inventory level would reduce total costs but at no point does theater inventory of the engine produce a lower cost distribution network design than always shipping the engine by air from CONUS.

Thus, to the extent that fast RWT is desired either to replenish tactical inventories—both of these items are readiness drivers stocked in SSAs—or to satisfy customer orders when SSAs are out of stock, the battery should be stocked in DDKS and the aircraft engine should not be.

The caveat is that if the engine were in “long supply”—that is, there were more serviceable engines in CONUS distribution centers than the RO—then some of them could be redistributed by surface to DDKS and other theater-level inventories without additional inventory investment needed to cover the surface pipelines. This would then allow what could be called opportune theater inventory fills. This caveat could be relaxed somewhat with stocks moved to theater inventory by surface, even if below the RO, if they were relatively healthy and most global demand were coming from SWA. This would require a check to ensure that there would be enough stock available to fill orders while stock on the ship is unavailable.

The process that has been illustrated is as follows (nominally using the last 12 months of data):

1. Determine the per-shipment transportation cost difference between strategic air and sealift with intratheater air. The strategic air costs per pound vary somewhat among items depending upon their density and shape and thus their impact on pallet weights. For each item, the

Strategic Distribution Database (SDDB) can be used to determine the actual airlift costs, which are apportioned in each shipment among items on a pallet.<sup>20</sup> Based upon information from USTRANSCOM, we used \$1.65/pound for intratheater airlift, but this should be updated over time using actual data as a theater evolves. We also assumed \$0.12/pound for sealift based upon historical costs.

2. Develop forecasts of the theater fill rate for an item as the inventory level is increased and compute the associated annual inventory holding costs.
3. For each inventory level, determine the annual transportation costs, assuming non-theater fills are shipped from CONUS via airlift.
4. Using DLA net landed costs for issue and receipt transactions,<sup>21</sup> determine the additional annual materiel handling costs associated with the additional receipt and issue transactions for replenishment shipments from CONUS to a theater inventory site for each inventory level in step 2.
5. Determine the inventory level for which the total of the inventory holding, materiel handling, and transportation costs is the lowest. This payback period may be limited through the use of a maximum payback

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<sup>20</sup> RAND developed the SDDB under the sponsorship of USTRANSCOM and DLA with the aim of providing exhaustive, detailed records on performance and cost for DoD sustainment distribution actions. In this context, the SDDB provides information on costs to fly sustainment materiel to OIF customers, including shipment costs from the issuing source of supply to the consolidation point (at DDSP or the CONUS APOE), trucking costs from the DDSP consolidation point to the CONUS APOE, and Air Mobility Command airlift charges, which are paid by the customer's service (HQDA G-4 receives the bills in the case of the Army). Air Mobility Command rates are defined by start- and endpoint combinations (e.g., Dover Air Force Base to Baghdad International Airport) and by the size of the shipment as it arrives at the APOE. AMC prices airlift based on five weight groups, with per-pound charges descending as the shipment gets heavier. For bulky items, AMC charges by the "dimensional weight" equal to ten times the cubic dimensions. Airlift rates are revised annually. Total transportation costs are linked to the original requisition and may involve apportioning costs at the triwall, pallet, or seavan level down to the individual shipment.

<sup>21</sup> Net landed costs are activity-based costs that DLA updates on an annual basis to charge for distribution depot services.

period to reduce inventory and thus financial risk, particularly when long-term demand levels are highly uncertain. For example, for SWA, we have employed a maximum payback period of two years in implementation efforts. If no inventory level produces a positive net benefit or meets the payback threshold, then the item should not be stocked in theater inventory with surface replenishment from a total cost standpoint.

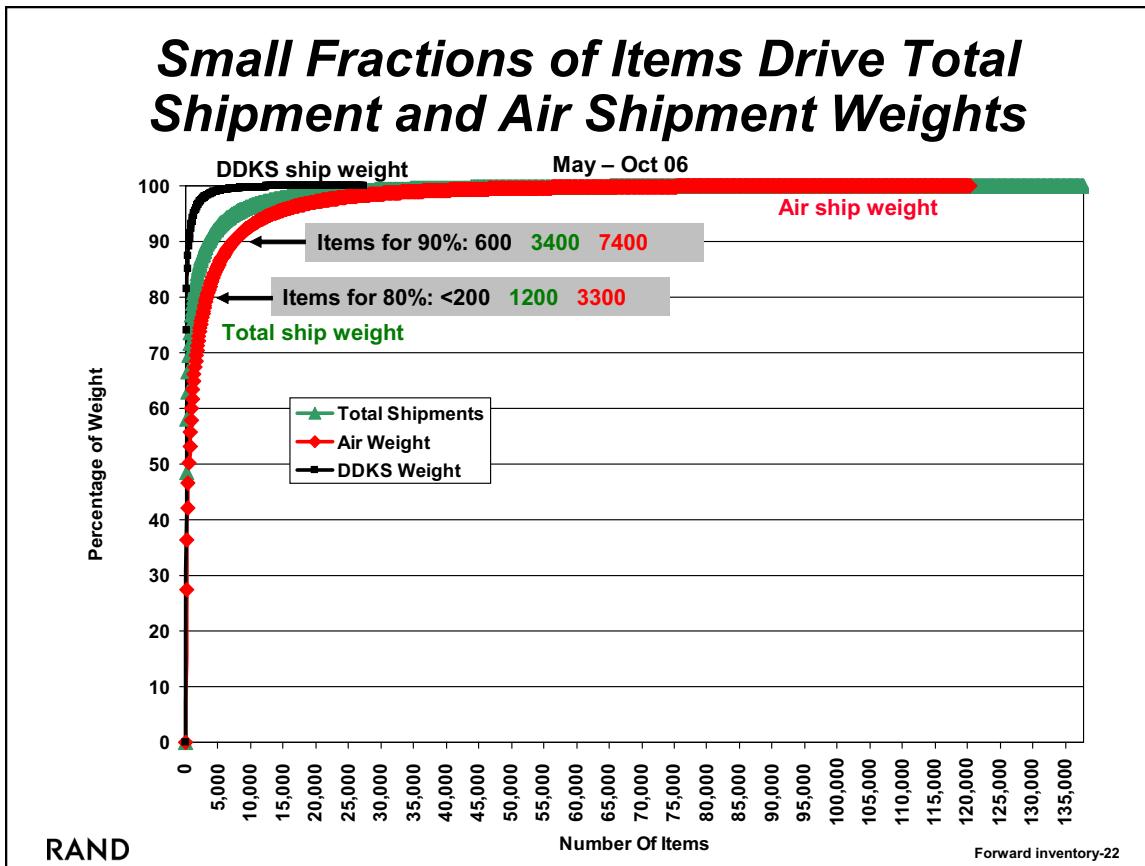
## ***Inventory Vs. Transportation Tradeoff Computations Produce Logical Classes for Theater Inventory***

- **Clear cases with theater inventory benefit**
  - Track, tires, and wheels
  - Construction and barrier materiel
  - Batteries
  - Packaged POL products
  - Tents
  - Paper products and other cheap bulky items
  - Cleaning supplies
- **Positive but more borderline theater inventory benefit**
  - Diesel engines and transmissions
  - Relatively heavy, dense engineered automotive components
- **Clear cases for which theater inventory increases costs**
  - Aircraft / turbine engines and transmissions, rotor blades
  - Electronics and small, expensive items
  - Small, low-demand items

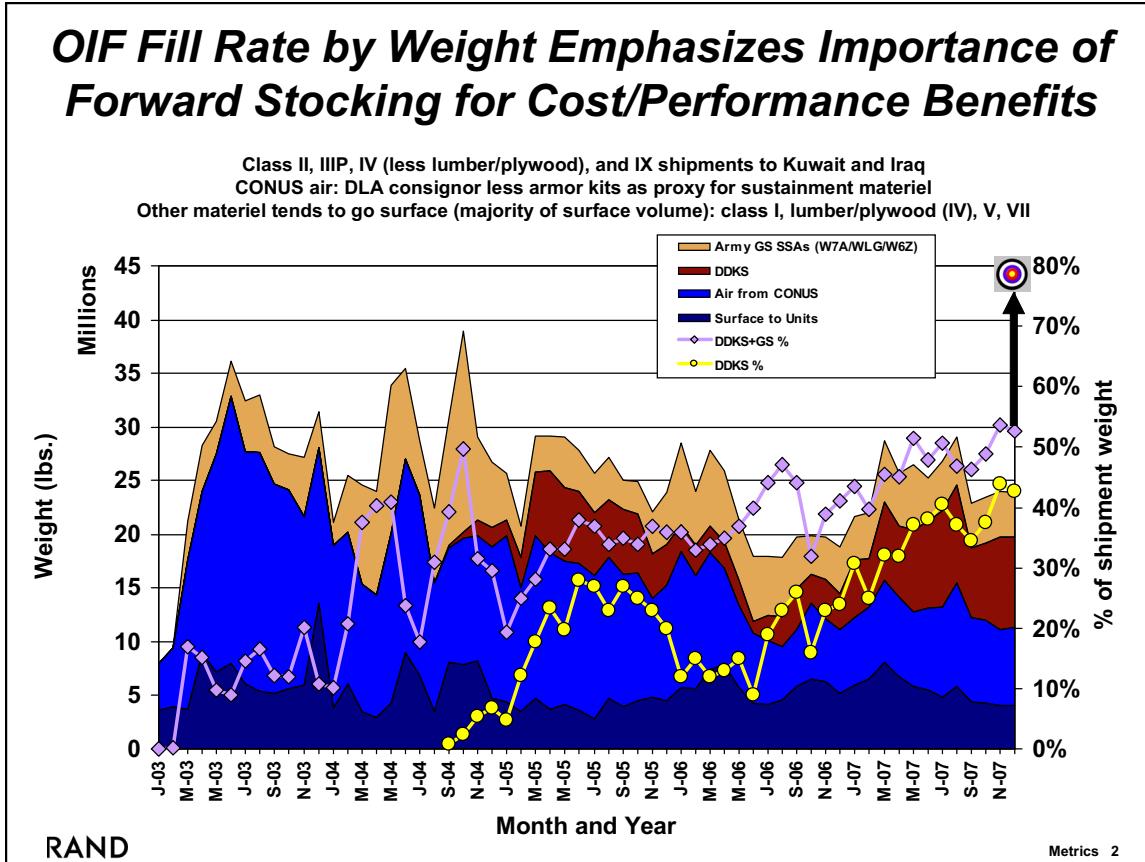
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Forward inventory-21

Applying the methodology described on the previous page for deciding what items and at what levels to forward position items in theater inventory for SWA produces what tend to be logical classes of items for theater inventory. Items with low price-to-weight ratios and large, relatively steady demand rates produce the greatest return on investment in theater inventory. These include items such as track, tires, and packaged petroleum, oil, and lubrication products. Many engineered automotive products, such as control arms or springs, and truck engines and transmissions, have lower costs with theater inventory, but the relative return is smaller. Large but very expensive items such as the M1 tank engine (most other items in this category are for aircraft) have increased distribution costs with theater inventory replenished by surface. Even more extreme examples of theater inventory investments that would increase distribution costs would be theater inventory with surface replenishment of electronics and other small, expensive items.



There is one additional element that is important to a systematic decision process. Not surprisingly, total shipment and air shipment weights are concentrated. Just 1,200 of over 135,000 different items shipped in from May to October 2006 for OIF accounted for 80 percent of the total weight, as shown by the green series. DDKS benefit has been even more concentrated to date, with a few hundred items providing most of the benefit. Thus, we can start by looking at weight drivers.



To develop recommendations for improving DDKS theater inventory focused on reducing total distribution costs, we identified the top 100,000 national item identification numbers (NIINs) by total shipment weight in the most recent thirteen months at the time of the analysis. Items beyond this list are not good candidates for theater inventory, and they have extremely little impact on transportation costs. We applied our methodology to determine which of the 100,000 would have lower total distribution costs with theater inventory. As of January 2008, close to 79,500 were found to be uneconomical to forward position; most are slow moving with insufficient demand to warrant forward positioning, and others with potentially sufficient demand are like the engine example, with the cost of theater inventory higher than the potential transportation savings. The remaining 20,500 that should be positioned in theater inventory had \$259 million in airlift costs and 46,000 tons shipped via surface direct to units from January 2007 to December 2007.

Of these 20,500, 1,500 are Army-managed, about 15,000 are DLA-managed, and 4,000 are GSA-managed items, with a few items managed by other services.

Applying the inventory levels resulting from our methodology would produce about an additional \$225 million per year in strategic airlift savings, while preserving air-like RWT.<sup>22</sup> Some of these savings would be offset by increased air costs from DDKS to Iraq, material handling, and inventory holding costs. Using the conservative assumption of 100 percent intratheater air for these items currently being shipped by air from CONUS, additional intratheater air would cost about \$85 million and inventory holding costs for the increase in inventory investment would be about another \$35 million, producing a net savings of a little over \$100 million. This is on top of \$400 million per year in strategic airlift cost avoidance and \$200 million per year in net savings already being achieved through improved DDKS inventories,

Additionally, the inventory levels above would also displace most of the 46,000 tons going surface direct from CONUS. Here the benefit would be improved response time to the theater. Thus, adding or increasing theater inventory, as appropriate, would not only save money, but would also switch slow surface direct shipments to customers to much faster distribution from DDKS, improving overall customer service. This would potentially affect 36,000 tons of shipments. If these 36,000 tons were switched from surface direct to strategic air instead of to theater fills to improve responsiveness, this would equate to a net annual airlift cost increase of \$150 million.

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<sup>22</sup> The top 100,000 items accounted for 99 percent of the total shipment weight. The 20,500 items that should be in DDKS accounted for about 90 percent of the weight for the top 100,000 items. Given relatively high demand variability, our recommended inventory levels would produce an 88 percent satisfaction rate for the stocked items, resulting in filling 78 percent of the total weight from DDKS.

To roughly estimate the cost savings, we assumed that demand would continue at the 2007 rate and that 78 percent of the total weight would be shipped from theater inventory, whether from DDKS or the GS SSAs. In an initiative beyond the scope of this document, the Army has begun shifting some of its retention materiel to DDKS, and this retention flow is difficult to forecast by item. Thus, we in effect assumed no additional weight shipped from the GS SSAs beyond that shipped from DDKS.

## Specific Examples Illustrate Need to Work at NIIN Level of Detail

- Uneconomical to forward position
- Too few shipments (one time)
- Not on DDKS forward stock list
- Replenishment/depth problem
  - Insufficient national stocks
  - ROP too low
  - Potential process issue

Manager	NIIN	FSC	Nomenclature	Unit Price	Unit Weight	Cost/lb.	# Air Shipments	Qty Shipped by Air	% Shipped Air	Cost of Air	DDKS RO	DDKS ROP	Avg 2-Month Qty	DDKS OH	OH DLA DCs
Army	015031701	2840	ENGINE, AIRCRAFT, TURB	\$694,615	722	\$962.1	91	122	91%	\$463,790	0	0	45	0	20
Army	013320702	1615	BLADE, ROTARY WING	\$108,246	360	\$300.7	41	91	92%	\$272,081	0	0	33	0	137
Army	010945547	2840	COLD SECTION MODULE,	\$249,321	615	\$405.4	52	58	71%	\$191,341	0	0	27	0	4
Army	013176446	1615	TRANSMISSION, MECHAN	\$688,605	1844	\$373.4	18	18	72%	\$168,841	0	0	8	0	4
Army	012497721	1340	ROCKET, FLARE, 2.75 IN	\$808	132.5	\$6.1	1	810	55%	\$96,976	0	0	495	0	0
DLA	011163171	4933	STAND, TURRET, FIRING	\$13,496	1617	\$8.4	1	1	100%	\$18,215	0	0	0	0	16
Army	014372261	2510	CAB ASSEMBLY	\$33,004	2520	\$13.1	1	1	100%	\$19,537	0	0	0	0	5
Army	015251995	2590	RETAINER, SPARE TIRE	\$1,815	190	\$9.6	828	1338	57%	\$1,028,233	0	0	789	0	1512
Army	014546320	1095	RACK, STORAGE, SMALL A	\$1,009	492.5	\$2.1	119	189	72%	\$568,929	0	0	88	0	18
Army	007533928	1670	PAD, ENERGY DISSIPATI	\$146	125	\$1.2	19	126	44%	\$310,409	0	0	96	0	18739
Army	015077423	2920	STARTER, ENGINE, ELECT	\$405	58	\$7.0	280	1084	49%	\$241,944	0	0	733	0	8022
DLA	015217668	2510	WINDOW, VEHICULAR	\$802	50	\$16.1	670	1696	76%	\$264,253	62	35	743	0	209
DLA	010788660	9390	TAPE, REFLECTIVE	\$145	4.26	\$34.2	105	1769	73%	\$30,751	18	8	812	0	0
DLA	012227946	2590	CABLE KIT, ELECTRICA	\$343	26.6	\$12.9	76	472	69%	\$27,824	222	0	228	222	3374
DLA	011524119	9150	LUBRICATING OIL, ENGI	\$236	450	\$0.5	36	303	53%	\$288,276	946	616	190	0	85
DLA	006815999	9150	LUBRICATING OIL, AIRC	\$793	501	\$1.6	9	21	18%	\$32,670	230	150	39	0	1843
DLA	014959566	5660	BARBED WIRE, CONCERT	\$93	32	\$2.9	8	181	43%	\$22,591	893	510	140	0	2379
DLA	005356797	2510	SIDE RACK, VEHICLE BO	\$249	44.4	\$5.6	11	17	40%	\$21,124	91	59	14	0	1711

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Forward inventory-24

These are item-level examples, based upon a snapshot of six months of data from May to October 2006, for further clarity and to show the range of issues that need to be addressed. The first four Army-managed items have relatively high air costs but are not economical to forward position with surface replenishment due to high unit prices and costs per pound. They are like the aircraft engine example presented earlier. Investing in inventory for DDKS for these items would lead to an increase in inventory holding costs that would be greater in magnitude than the opposing decrease in transportation costs.

The next three items only had one air shipment each and two of them only had one shipment total, so stockage requirements would be uncertain and theater inventory would be financially risky. That is, with just one or two shipments, or even a few, in six months, it is impossible to forecast when future demands might occur as well as how big they might be. Thus, there would be a much greater risk of investing in inventory that is never needed or sits on the shelf for a prolonged period of time, greatly increasing inventory holding costs

or leading to inventory “writeoffs.” Rather than stocking these items, extreme vigilance should be taken to identify future potential needs far enough in advance to fill via surface direct. If this cannot be done and the requirement must be met quickly, then the use of strategic air becomes necessary.

Next on the list are four items with high air costs, low costs per pound, and not on the DDKS list, as seen by the zeroes in the RO column. These items should be added to DDKS. Next are three items with ROPs that are too low to satisfy most orders from DDKS, resulting in high air percentages despite DDKS stockage. This can be seen by comparing the two-month average demand quantities, which should generally be a very conservative lower bound for the ROPs. The DDKS inventory requirements for these three items should be increased. Next, for one of the “adds,” two of the “increases,” and one additional item, there is not enough stock on hand in the total supply system to effectively use DDKS. These are indicated by the orange in the column for total on-hand stocks in CONUS distribution centers. These numbers are much less than the needed ROPs. Adequate replenishments or initial stocks cannot be provided given the national inventory on hand levels. Thus, global inventory requirements should be reevaluated. Finally, there are three items that are on the stockage list, with sufficient ROPs, and sufficient stocks on hand in CONUS for replenishment, yet DDKS on hand is zero. These represent a replenishment process issue.

## ***Adopt a Standard Process & Stockage Policy for Surface-Theater Stockage Decisions***

- Periodically review items to add / delete / change depth
  - Service, DLA, and GSA managed
- Focus on items with high shipment volume (total weight)
- Select items based upon total cost impact
  - Determine transportation cost savings from sealift
  - Determine inventory cost of marginal inventory needed to support sealift-based replenishment and theater inventory
  - Determine additional handling costs
- Set depth to achieve all system goals (long-term: internal to ERPs)
  - Theater target: satisfaction for selected items
    - Objective in terms of weight filled locally, not requisitions
  - Global levels to achieve system stock availability and theater satisfaction goals

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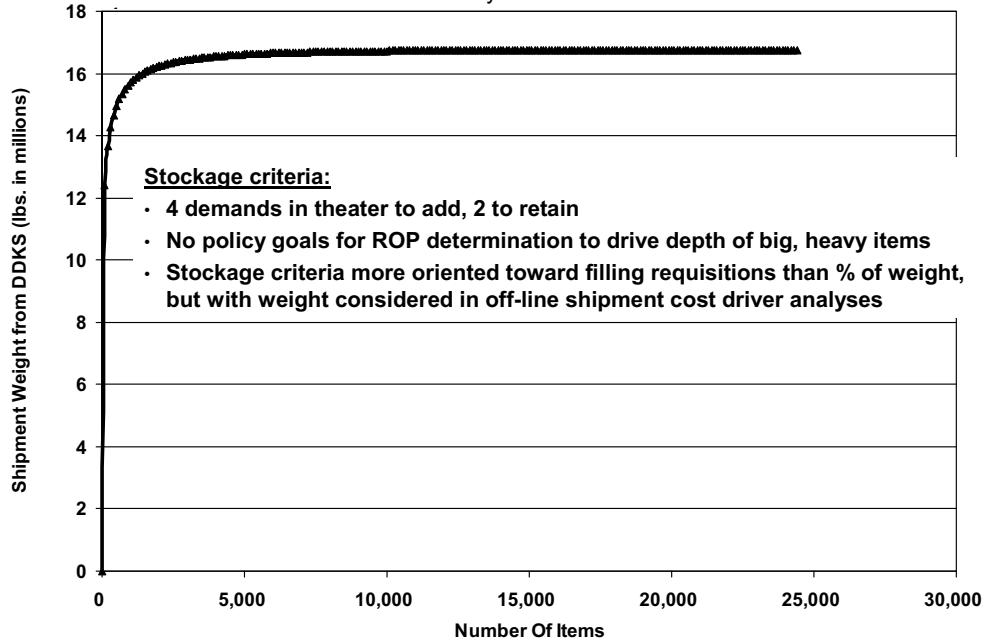
Forward inventory-25

A standard process to execute this type of analysis should be adopted. It would start with periodic review and action. The first step would be to focus on weight drivers that drive transportation costs. Then items for which theater inventory would produce lower total distribution costs based upon transportation, inventory, and materiel handling costs should be identified. For these items, depth or ROPs in DDKS should be set to achieve a target satisfaction rate to ensure that most shipments go by surface to theater. This focuses the theater stockage objective on weight, not requisitions filled. Additionally, the managing agency also needs to set global levels sufficient to provide necessary replenishments to DDKS upon demand. The safety levels chosen will directly determine the percentage of shipments for these items that can go surface while still providing short RWT when units order the items. For very cheap, heavy, critical, high-demand items that would have to go by air if DDKS were out of stock, the optimal DDKS fill rate targets are very high, as the airlift versus inventory cost tradeoff is extremely one-sided in favor of

buying more inventory. This in turn would imply a very high national stock availability target for the item, such as 95 percent or even higher. One can think of the need to fly the item when DDKS is out of stock as an additional backorder cost. The cost of additional inventory is much less than the cost implications when inventory falls short, which results in the need for airlift.

## **Current DDKS Stockage Criteria Reflect RWT Benefits Instead of Cost Benefits**

May – Oct 06



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Forward inventory-26

As of late 2006, a small percentage of the items stocked at DDKS provided most of the cost benefit. This is because the stockage criteria were primarily requisition-fill focused rather than weight focused. This would be appropriate if DDKS had a speed advantage to offer and it were used for a readiness benefit instead of to save money. The stockage criteria were 4 demands to add, 2 to retain for DLA items, and, most critically, without mechanisms to tie ROPs to percentage of weight filled from theater or to tie ROPs to the optimal theater inventory fill rates. While these criteria pick up all of the weight drivers, it adds many items for which theater inventory may increase total distribution costs, and investments in these items compete with investments in the big, heavy weight drivers. The decision logic recommended in this section of the report would suggest eliminating the current add/retain criteria and shifting to a list of NIINs based upon a total cost analysis. Similarly, the ROP calculations should shift to an emphasis on weight filled from theater and minimizing total costs.

## ***Improved Theater Stockage Benefits DoD, But Below DoD Level, Savings and Costs Are Split***

- Forward stocking savings accrue to the ordering service
  - Reduced OOT charges
- Forward stockage investment can require working capital fund, obligation authority infusions, and possibly cash infusions
- Most of the benefit will be to the Army (OOT charges paid through Army G-4) as the driver of OCONUS volume
  - Some benefit to the other services
  - No financial benefit to DLA
- Working capital fund requirements will primarily be for Army Materiel Command and DLA, with GSA also being affected
- DPO should advocate for agency/service OA, and cash as necessary, when it will decrease total supply chain costs

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Forward inventory-27

There is one potential barrier to effective DoD implementation of these general processes and the specific DDKS recommendations we provided to AMC, GSA, and DLA. Savings from theater inventory ultimately accrue to the ordering service through reduced over the ocean transportation charges (OOT). Due to the nature of OIF, much of the benefit from improved DDKS inventory will accrue to the Army. However, the investment has to be made by DLA, GSA, and the Army, and even within the Army, the investment comes from the Army working capital fund while OOT is paid through the Office of the Deputy Chief of Staff, G-4 with operation and maintenance budget dollars. Thus, there could be a role for the distribution process owner (DPO) to advocate for working capital fund obligation authority (OA) and even working capital fund cash or total obligation authority (TOA) when needed to seed theater inventory in order to reduce total distribution costs.

## 4. Policy Changes to Leverage Forward Distribution Depots

### *Outline*

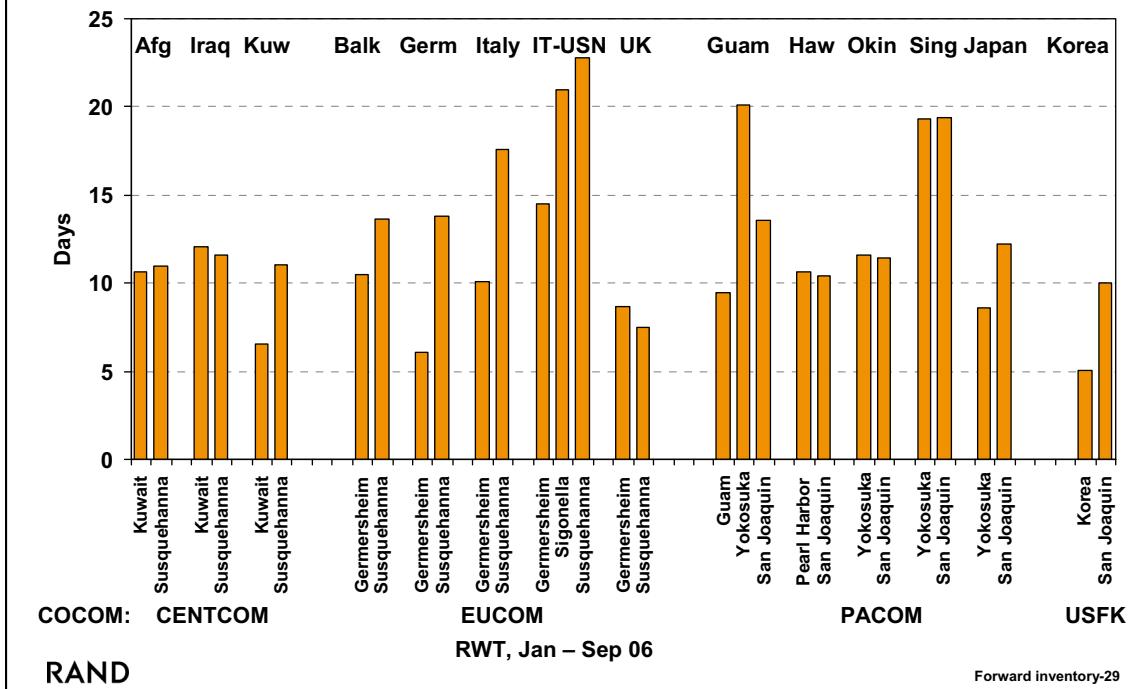
- Distribution system design tradeoffs
- Reducing total supply chain costs through targeted theater inventory investments and surface replenishments
- ➡ • Policy changes to leverage forward distribution depots
- Reduced costs through improved planning and coordination

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Forward inventory-28

We now move from looking specifically at theater inventory intervention to reduce OIF costs and improve OIF distribution performance to more general policy for FDDs.

## ***Forward Depots Provide a Time Advantage When Local Ground Networks Available***



It is often believed that FDDs provide a time advantage over CONUS. However, this is not always the case for stock held at SDPs and sent via pure pallets. This chart shows average RWT for each FDD to different areas they serve and compares these times to RWT from the supporting SDP for the region—either DDSP, which supports units in the east half of CONUS, Europe, Africa, and West Asia, or the SDP in San Joaquin, California (DDJC), which supports units in the west half of CONUS, the Pacific, and East Asia. Generally, when the FDD can rely on a good scheduled truck-type network, the FDD provides faster RWT than achieved with strategic from its corresponding SDP. Otherwise, performance is often similar from the FDD and the corresponding SDP such as for DDKS and DDSP to Iraq and Afghanistan, Germersheim, Germany and DDSP to the United Kingdom, and Yokosuka, Japan and DDJC to Okinawa and Singapore.

## ***FDD Cost and Performance Profiles Suggest Varied Stockage Objectives by FDD***

	Afgh	Iraq	Kuw	Balk	Ger	Italy	UK	Korea	Guam	Haw	Japan	Okin	Sing
<b>Kuwait DDKS</b>	\$	\$	\$ RWT										
<b>Germ DDDE</b>				\$ RWT	\$ RWT	\$ RWT	\$						
<b>Sigon DDSI</b>						\$							
<b>Korea DDDK</b>								\$ RWT					
<b>Yokos DDYJ</b>									+\$ +RWT		\$ RWT	\$	+\$
<b>Guam DDGM</b>									\$ RWT				
<b>Pearl DDPH</b>										\$			

\$ – indicates transportation cost advantage  
RWT – indicates distribution time advantage

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This chart summarizes how the FDDs compare in performance and cost to the respective SDPs for the theater (assuming strategic air from the SDP), with a green dollar sign showing a cost advantage and green RWT indicating a performance advantage for the FDD. Red indicates either a higher RWT or transportation cost for the FDD as compared to the relevant SDP. As the benefits vary, so too should the stockage objectives for the FDDs.

## ***Stockage Performance Targets Should Be Aligned with Potential Benefits***

- **Total cost benefit**
  - Theater target: satisfaction for selected items and/or weight basis
  - **Selected items:**
    - Focused on shipment drivers
    - High weight-to-cost ratio
  - **Global inventory levels to achieve system stock availability and theater satisfaction goals**
- **Total cost and RWT benefits**
  - Apply total cost benefit rules above
  - Additional theater target: fill rate for all critical items
  - **What RWT advantage makes increased total costs worth it?**
    - Small net cost savings items (i.e., low volume, high weight/\$)?
    - Net cost increase (e.g., electronics LRU)?

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Forward inventory-31

When the FDD presents a total cost benefit, stockage objectives should be as described earlier for DDKS. Ideally, items with lower total costs when stocked in the FDD would be selected for FDD inventory, and their depths or ROPs should be based upon minimizing total costs. This differs from many variable safety level approaches, which maximize requisitions filled for minimum inventory investment. Instead, the goal should be to maximize weight filled for minimum inventory investment—or more specifically, stock to the level that minimizes total costs. Additionally, national providers need to adjust global stockage levels as necessary to support FDD replenishment needs. Again, some of these items merit very high national stock availability targets to avoid DDKS and even national backorders that would result in high airlift charges relative to the costs of avoiding stockouts.

If the FDD also presents an RWT benefit, then stockage might be expanded beyond the list from the total distribution cost criterion. First, the total cost benefit rules should be applied. Then critical items that do not

qualify for FDD stockage based upon reduced total distribution cost could be added to gain a readiness benefit through faster RWT. This could increase costs, so a cost-performance tradeoff judgment will have to be made. This analysis would have to account for the potential benefit of decreased RWT on inventory levels closer to the customer (e.g., retail inventories carried by the SSA in the Army) and reduced customer wait time (CWT) if an item is not stocked elsewhere in theater. We ask rhetorically: How much, if any, additional cost is acceptable to gain the RWT/CWT advantage offered by the FDD? Additionally, for these items, the FDD should be replenished by air to minimize inventory costs. Since these items would not have been selected through the total cost analysis, for many of them, this indicates that the inventory to support surface replenishment would be unduly expensive. Thus, if these items were positioned in theater inventory for a RWT advantage, the increase in inventory cost could be minimized by using strategic air for replenishment.

## 5. Summary of Recommendations

### Recommendations

- **Immediate actions**

- Add/increase theater and global inventory of specified NIINs to save up to a roughly estimated \$100M per year net of strategic air reduction, intratheater air increase, and inventory increase
    - Will also improve RWT by reducing surface direct fills

- **Policy and process changes**

- Establish standard process for updating FDD inventory requirements across services and agencies
    - DPO should advocate for agency/service OA, and cash as necessary, when it will decrease total supply chain costs
  - Establish joint FDD policy aligned with FDD benefits
    - Cost and/or RWT goals
    - Stockage objectives tied to goal(s)
    - Metrics aligned with supply chain intent: FDD weight %
  - Providers pay over OOT costs, with responsiveness agreements
    - OOT costs are a function of stock positioning, not customer priorities
    - Good stock positioning enables responsiveness at lowest cost

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Forward inventory-32

In summary, as of January 2008, there were immediate opportunities to cut sustainment airlift to SWA by about two-thirds, cutting overall airlift by about one-third by improving theater inventory of sustainment items. This does require increased national inventory levels and inventory investment to be effective and would be partially offset by increased intratheater air costs, but a substantial net savings would result. For items with recommended inventory changes that are sometimes shipped by air to SWA and sometimes directly to customers via sealift, these changes will also improve RWT by shifting the surface direct shipments to shipments from DDKS.

In the short term, the standard process for determining FDD inventory should be refined, with the DPO potentially aiding by removing roadblocks to implementation, such as helping to address OA needs. Longer-term, standard

policy for FDDs should be agreed to, and this policy should be used to guide stockage decisions, which should be aligned with the benefits each FDD provides. At a minimum, all FDDs should stock items with high shipment weight and low unit prices to reduce total costs. FDDs in locations with transportation networks that enable them to have a distribution time advantage over airlift from a CONUS SDP might also have somewhat broader stock to provide better customer support, with the additional items replenished by airlift instead of via sealift. Ultimately, the services and DLA should look to have this policy reflected in the logic within their enterprise resource planning based materiel planning systems such as the Executive Business System (EBS) for DLA and the Logistics Modernization Program (LMP) for the Army so that the right items at the right depth can be maintained in FDDs through a standard, automatic process.

To better align incentives and responsibilities for FDD inventory management, the percentage of weight filled from each FDD should be established as a DPO metric, with results stratified by provider. Reports should be accompanied by the airlift cost and RWT impacts of shortfalls in theater inventory. Additionally, OOT costs should be borne directly by providers as they are determined primarily by stock positioning. This would produce a better incentive for supply managers and organizations to minimize total supply chain costs rather than focusing on minimizing inventory costs.



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